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Report No. 12

FIFTH
ANNUAL REPORT
OF THE
SCIENTIFIC AND INDUSTRIAL RESEARCH COUNCIL OF ALBERTA
1924

PRINTED BY ORDER OF THE LEGISLATIVE ASSEMBLY

EDMONTON:
PRINTED BY J. W. JEFFERY, KING'S PRINTER
1925

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ORGANIZATION

The Scientific and Industrial Research Council of Alberta, formed in January, 1921, carries on its work in co-operation with the University of Alberta.

The personnel of the Council at the present time is as follows:

Hon. Herbert Greenfield, Premier of Alberta, Chairman.
H. M. Tory, President, University of Alberta.
J. T. Stirling, Chief Inspector of Mines, Province of Alberta.
J. A. Allan, Geologist.
N. C. Pitcher, Mining Engineer.
R. W. Boyle, Dean, Faculty of Applied Science, University of Alberta.
Edgar Stansfield, Honorary Secretary, Industrial Research Department, University of Alberta.

Requests for information and reports should be addressed to the Honorary Secretary, Industrial Research Department, University of Alberta, Edmonton, Alberta.

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UNIVERSITY OF ALBERTA,
EDMONTON, ALBERTA,
JULY 30TH, 1925.

HON. HERBERT GREENFIELD,
Premier of Alberta,
Edmonton, Alta.

Sir :—

Under instruction from the Scientific and Industrial Research Council of Alberta, I herewith submit their Fifth Annual Report. This covers the work done under their direction during the year ending December 31st, 1924.

Respectfully submitted,

EDGAR STANSFIELD,
Honorary Secretary.

FIFTH ANNUAL REPORT OF THE SCIENTIFIC AND INDUSTRIAL RESEARCH COUNCIL OF ALBERTA

PERSONNEL AND MEETINGS OF COUNCIL

Five meetings of the Council were held during the year. The personnel remained unchanged, and is as given below:—

Hon. Herbert Greenfield, Premier of Alberta, Chairman;
H. M. Tory, President, University of Alberta;
J. T. Stirling, Chief Inspector of Mines, Province of Alberta;
J. A. Allan, Geologist, University of Alberta;
N. C. Pitcher, Mining Engineer, University of Alberta;
R. W. Boyle, Dean, Faculty of Applied Science, University of Alberta;
Edgar Stansfield, Honorary Secretary.

STAFF

The following changes in the permanent staff have been made during the year:—

R. L. Rutherford commenced work as Geologist on May 1st. This appointment was a transfer from seasonal to permanent employment.

W. L. McDonald resigned his position as Assistant Engineer in the Fuels Division on May 24th.

W. A. Lang commenced work as Assistant Engineer in the Fuels Division on November 6th, in place of W. L. McDonald, resigned.

W. G. Jewitt resigned his position as Assistant Engineer in the Road Materials Division on September 30th.

H. D. Moon resigned his position of Laboratory Assistant on September 30th.

J. D. Baird commenced work as Laboratory Assistant on October 1st.

Marjorie D. Walker commenced work as Geological Stenographer on October 1st.

The permanent staff on December 31st, 1924, was as follows:—

Edgar Stansfield, Research Engineer, *Fuels;*
K. A. Clark, Research Engineer, *Road Materials;*
R. T. Hollies, Assistant Research Engineer, *Fuels;*
R. L. Rutherford, Geologist, *Geology;*
S. M. Blair, Assistant Research Engineer, *Road Materials;*
W. P. Campbell, Fuel Analyst, *Fuels;*

W. A. LANG, Assistant Engineer, *Fuels;*
J. B. COGHILL, Recording Secretary;
MARJORIE D. WALKER, Geological Stenographer;
J. D. BAIRD, Laboratory Assistant.

In addition to the above, Professors J. A. Allan and N. C. Pitcher, of the University of Alberta, Members of the Council, are in permanent charge of the Council's research work in Geology and Mining Engineering, respectively.

Other members of the University Staff have assisted from time to time: notably Prof. R. S. L. Wilson devoted considerable time throughout the year to work for the Council on the forest products of Alberta, with special reference to mine timber; A. G. Scroggie, a graduate student of the University, carried on, under the auspices of the Council, an investigation on the clinkering properties of coals.

A number of other persons held summer or short term appointments under the Council:—

In the Fuels Division: F. L. Grindley, Briquetting Assistant.

In the Geology Division: J. O. G. Sanderson, Geologist in charge of a field party; Leo Telfer, Assistant Geologist; E. Jones, Assistant Geologist; Miss M. D. Fife, Stenographer.

In the Road Materials Division: G. J. Knighton, Draftsman and Surveyor; J. V. Lehmann, Chemist; A. J. Morton, Chemist; M. Ray, Laboratory Assistant, etc.

In the Forest Products Division: R. K. Muir rendered occasional service.

In the Office: R. W. Howie acted as Junior Office Assistant.

ORGANIZATION

In the organization of the University of Alberta the staff of the Research Council constitutes the Industrial Research Department, and the Research Council's laboratories are referred to as the Industrial Research laboratories.

In the organization of the Provincial Government the work of the Research Council was attached to the Department of the Provincial Secretary. At the close of the year 1923 it was transferred to the Executive Council, where it is under the direct supervision of the Premier.

LABORATORIES AND EQUIPMENT

The most notable addition during the year was that of the bituminous sand separation plant erected at the Dunvegan Yards of the E. D. & B. C. railway in Edmonton. This plant is referred to later.

The laboratory accommodation and facilities available at the University for the work of the Council were slightly increased during the year by the installation of one double-sided work bench, 22 feet long, with gas, water and electrical connections, and also some tables and shelves.

The principal items of new laboratory equipment acquired during the year are as follows:—Lessing coking test apparatus, Freas thermostat, Leeds & Northup duplex recording pyrometer, Howard & Morse ductility apparatus, Stormer viscosimeter, two Sartorius balances, two Bristol recording thermometers, swing saw, and Canadian General Electric 15 h.p. motor, acquired by purchase; also many pieces of apparatus designed and largely constructed at the University. Additions were also made to the library.

FUELS

The work of previous years was continued, and some fresh work begun. Only one carload sample was received and tested, as it was decided to devote more time to other branches of the work during the year. This sample was subjected to screening, storage, and other tests, as in previous years. Nine special samples were received and tested: one for smithy purposes, and eight for heavy solution tests to indicate their suitability for purification by washing. Also, Georges Creek, Md., coal was purchased for smithy tests, and Edmonton coal for domestic heater tests.

Storage tests were continued, and two-year tests were completed on two domestic coals during the year. The methods of carrying out and reporting the tests were not changed.

No boiler trials were made this year.

Considerable progress was made during the year with the work on domestic heaters, both in actual tests and in development of methods and technique of testing. In addition to tests in the laboratory on both hot water and hot air furnaces, tests were made on furnaces installed in a residence in Edmonton. These latter tests were largely designed to collect data to ensure that the laboratory tests were carried out under conditions resembling those found in ordinary service. A three-phase, 20 k.w. electric resistance heater was designed and constructed for use inside the laboratory furnaces. This was intended for testing the accuracy of the measurements made, and also to test such matters as loss of heat by radiation, etc.

Marked progress was made during the year with briquetting, although the further this work is carried, the more difficult it is found to be. There are many variable factors to be adjusted, and a change in any one of these appears to change the most favourable adjustment for the others. Two hundred and twenty-five batches of briquettes were made during the year: one hundred and fifty-one with sub-bituminous coal from the Coalspur area; thirty-nine with similar coal from the Saunders area; twenty-eight with bituminous coal, mainly from the Crowsnest area; and seven with carbonized lignite. The principal binders used were soft coal tar pitch; asphalt, including asphalt from McMurray bitumen and Wainwright oil; hard coal tar pitch; lignite pitch; and sulphite pitch. These binders were used alone and in combination with sawdust, flour, starch, oatmeal, bentonite, and water glass, or preparations of these. Briquettes are tested to show their strength and handling qualities, their ability to stand prolonged exposure to the weather, and their firing qualities. Only those which pass all three tests are regarded as satisfactory.

The study of the physical properties of the binders which was begun at the end of 1923 was continued intermittently. The absence of suitable standardised tests for binders, and the difficulty of interpreting the results obtained in such a way as to indicate the merits of the binder, make progress slow, especially at the beginning.

Smithy tests were carried out on air-washed coal from the Greenhill mine at Blairmore. The excellent results obtained with this coal serve to further emphasize the absurdity of continued importation of smithy coal from the United States into the Province.

Study of the clinkering properties of ash from typical coals made slow progress during the year, and several coals have yet to be tested to complete the proposed programme. This study has been undertaken as spare time work by Mr. A. G. Scroggie, a member of the staff of another department.

Laboratory studies have been continued, with particular attention to accuracy of methods of analysis of coal, especially for moisture and volatile matter; relation between calorific value and ash content of coal; relation between mineral impurities in coal and the ash produced on burning; and to the moisture-holding properties of coal.

Work carried on for the Provincial Mines Branch included the analysis of 178 samples of coal and 7 samples of coal dust taken by the Provincial Inspectors of Mines from some 80 mines. Forty-five samples of coal were also analysed for the Geological Division.

The coal samples analysed during the past five years have been card indexed by mines and by areas, etc. These analyses, and many published in Ottawa, have been collected and arranged according to districts; a careful study has been made of them, and many ways of bringing them to a comparable basis have been tried. This work is all preparatory to the construction of maps showing the chemical characteristics of the coals throughout the Province.

A more detailed report of several branches of the work on Fuels is given as an appendix.

GEOLOGY

Details of progress in this division are given in the geology section of the appendix to this report.

The geological work of the Council was carried on in conjunction with the Department of Geology of the University. The requests from the public for information on mineral and allied resources in the province, as indicated in the correspondence, were varied, and more numerous than in previous years. The correspondence for the year included 594 letters received, and 705 letters sent out.

The large number of specimens received by J. A. Allan were examined and reported on free of charge. Those requiring a chemical analysis, for which a charge is made, were attended to by the Industrial Laboratories.

Two geological field parties were directed by J. A. Allan. One party continued the foothills belt survey started in 1922, and covered about 600 square miles between McLeod and Athabaska rivers. The second party was in the district along Red Deer river, between Carbon and Ardley, continuing the survey of the Drumheller coal area, made in 1921. Nearly 6,000 square miles were examined.

Besides supervising the geological work and visiting the two field parties, Dr. Allan investigated occurrences of aluminium sulphate on Smoky river, and of placer gold on Athabaska river near Smith. About ten days were spent with the Soils Survey party under the direction of Dr. F. W. Wyatt, making a general survey of the surface geological features in the southeastern part of Alberta. Observations were made on the relation of the surface deposits to the soils from Oyen, east of Youngstown, south through Empress, Medicine Hat, and Cypress Hills, to the International Boundary line, then west along the southern part of the province to Cardston and Waterton lakes.

In December, considerable time was spent by Dr. Allan in getting information for the Alberta Coal Commission.

Additional geological information was compiled for the geological map of Alberta now being prepared.

The Coal Areas map, prepared by J. A. Allan in 1923, and included in Report No. 10 of the Council, has been slightly altered. New areas were also added to meet the requirements of the Chief Inspector of Mines, who has adopted the coal areas for Mine Inspection districts. Details of these changes are given by Dr. Allan in the appendix to this report.

The only additional material acquired for the museum during the year consisted of:—

(1) Crude petroleum, from British Petroleum Well No. 4 at Wainwright.

(2) A suite of china clays and porcelain wares, in the different stages of manufacture, from Dr. J. W. Mellor, Stoke-on-Trent, England.

ROAD MATERIALS

A heavy programme of work was undertaken during the year. During the early months, laboratory tests were made on McMurray bitumen, and on Wainwright and other crude oils. These mainly consisted of distillation and refining tests, and determinations of the physical properties of the products.

A field party under S. M. Blair spent four months studying occurrences of bituminous sand on the Athabaska river and its tributaries. This investigation had as its primary object a study of the economic features of the deposits, particularly with reference to the feasibility and probable cost of commercial development. Thirty-five representative exposures were examined in detail, a shaft was sunk 45 feet through a deposit, and some 250 samples were collected for analysis.

A bituminous sand separation plant was designed, constructed, and operated under the immediate charge of W. G. Jewitt. The design was based on that of the small plant successfully operated the previous year at the University. The old plant could treat half a ton of sand per hour for short periods, whilst the new plant was designed for steady operation and to treat one ton per hour. The site selected was the Dunvegan Yards of the E.D. & B.C. Ry. in Edmonton. Many new difficulties were encountered in the larger scale operation, but 100 tons of sand were sent through the plant before the approach of winter necessitated stopping work. This plant will be reopened as early as possible in 1925.

The chemical laboratories were kept busy during the summer and autumn analysing the samples sent in by the field party and samples from the separation plant.

The experimental road laid down in 1923 came through the winter in good condition, although, owing to its short length and narrow width, much dirt was carried onto the treated surface from the untreated road. This work will be continued on a larger scale in 1925, with improvements suggested by the results of the earlier experiment.

Further particulars of the field work and of the separation plant will be found in the appendix.

FOREST PRODUCTS

The work outlined in the 1923 report was continued during the year by Professor R .S. L. Wilson. Tests are in progress on the suitability of lodge pole pine for mine timber under varied conditions, and many results have already been compiled. Further particulars of this work will be found in the appendix, but as it will take several years to complete any series of tests, it is not yet possible to publish any conclusions.

MISCELLANEOUS

J. A. Allan, N. C. Pitcher, and E. Stansfield visited coal mines at Nordegg and in the Drumheller valley in May, in company with some of the Mining Engineering students of the University.

Two papers were presented to the Western Annual Meeting of the Canadian Institute of Mining and Metallurgy, held at Blairmore in Alberta: "Characteristics of Alberta Coals," by Edgar Stansfield; and "Some Coal-Seam Correlation Problems in Alberta," by R. L. Rutherford.

K. A. Clark visited Lethbridge and Great Falls, Montana, studying oiled road construction methods.

ACKNOWLEDGMENTS

The Canadian Dinant Coal Co., Ltd., Dinant, contributed a carload of coal. Messrs. J. and A. Dunn, of the Great West Coal Co., Ltd., continued to provide facilities for timber testing at the mine. Courtesies were extended by many operators to our visiting representatives.

FUELS

By E. STANSFIELD and R. T. HOLLIES.

Prof. N. C. Pitcher, Chief Mining Engineer, assisted with suggestions and advice with most of the work described.

W. P. Campbell, Fuel Analyst, made all coal analyses reported, and carried out some laboratory investigations referred to.

W. L. McDonald, F. L. Grindley, and W. A. Lang each assisted in briquetting work for part of the year.

COALS TESTED

One carload sample of coal was received, donated by the operator. Two batches of samples were also submitted by the operators for special tests. These were as follows:—

Camrose Area:—
Canadian Dinant Coal Co., Ltd., Dinant, Alta.—1 carload.

Nordegg Area:—
Brazeau Collieries, Ltd., Nordegg, Alta.—sample consignment.

Crowsnest Area:—
West Canadian Collieries, Ltd., Blairmore, Alta.—sample consignment.

Provincial Inspectors of Mines submitted 178 coal and 7 coal dust samples for analysis. In addition 45 coal samples were analysed in connection with the season's work of the Geological Division. Many analyses were made in connection with the regular work of the Fuels Division, but no count is kept of these.

SAMPLING AND ANALYSIS

No change in method was adopted during the year. In respect to the determination of volatile matter, the quick heating method is used for bituminous coals, and the slow heating method for sub-bituminous and lignitic coals, as already described. Some doubt, however, often arose as to the method to be employed with border line coals. It was decided, from experience gained, that the slow heating method should always be used for any coal which retains more than 10% moisture after standard air drying.

A suggestion has been made that certain high volatile coals, such as those from the Drumheller field, lose not only moisture but also volatile matter when heated in the drying oven. This point had been checked in the past, by different experimenters, with coals from various parts of the world; but tests were also made in these laboratories with Drumheller coal. The previous work was confirmed, and the accuracy of the method confirmed, as it was found that the loss of volatile matter was negligible.

Natural gas is now used instead of carbon dioxide to pass through the drying oven when drying coals. This is merely for convenience and economy, and does not in any way affect the result.

GENERAL CHARACTERISTICS OF ALBERTA COAL

A study of the many hundred available analyses of Alberta coals was begun this year. A preliminary report on this work was presented to the Western Annual Meeting of the Canadian Institute on Mining and Metallurgy in October by E. Stansfield. A further report will be given at the Annual Meeting of the Institute in March, 1925, and will be published in the Bulletin of the Institute.

SCREENING

The following information is the result of the screening on Dinant Coal. It may be added to Tables I., II., III., and IV. of the Fourth Annual Report, pages 18 to 21.

Proportions of sizes in run of mine coal, on screening the car load sample, were found to be: Lump, 51%; Egg, 20%; Nut, 10%; Pea, 12%; Dust, 7%. A comparison of the ash contents of the different sizes of the coal (the calculated average content of all sizes being taken as 100) is: Lump, 79; Egg, 84; Nut, 107; Pea, 136; Dust, 226. The analyses of the different sizes of the screened coal showed that the proportion of the total ash in each size was: Lump, 40%; Egg, 16%; Nut, 11%; Pea, 16%; and Dust, 17%. The equivalent spacings for bar screens, as found for this one sample of Camrose Area coal are 30, 21, 16, 12, 9 and 3 sixteenths of an inch bar screen spacings, respectively equivalent to 3, 2, 1½, 1, ¾ and ¼ inch diameter circular perforations. These figures closely approximate those for the Pembina area, given in Table IV. of the Fourth Annual Report on page 21.

STORAGE

During the year one fresh sample of coal was placed in storage. Two batches were tested after completion of two years in storage, and several batches after shorter periods. No change will be made this year in the table of deterioration given on page 22 of the last years report, but it might be added that the corresponding figures for shed storage are approximately half those for open storage. These values refer to physical deterioration. Some interesting results are being obtained with regard to loss of heat value during storage.

Comparative figures were obtained of the calorific value of Drumheller coal: fresh, after one and two years open storage, and after two years shed storage. In each case a series of samples of widely varying ash content was prepared by means of heavy solutions. The results are shown graphically in Figure 1.

The comparison curve, its origin and meaning, are explained in the Third Annual Report (Report No. 8) on pages 29 to 31, and Figure 4 of that report gave the curve for freshly mined Drumheller coal. This line is repeated in Figure 1, and shows the remarkable fact that even after two years storage the calorific value of the coal substance has not materially changed. This does not indicate that no heat loss or depreciation has taken place during storage. Coal of this nature slowly absorbs oxygen when exposed to the air, and thus gains in weight. Later, chemical changes take place in the coal substance whereby water and possibly carbon dioxide are formed and liberated. The final weight of dry coal may then be less than the original weight. These reactions all generate heat, which is lost, so that although the heat value of unit weight coal substance may be unchanged or even increased, the total available heat from the whole mass of stored coal is undoubtedly less after storage. The heat generated during the reactions described above is the heat which, under suitable conditions, causes spontaneous combustion in storage piles.

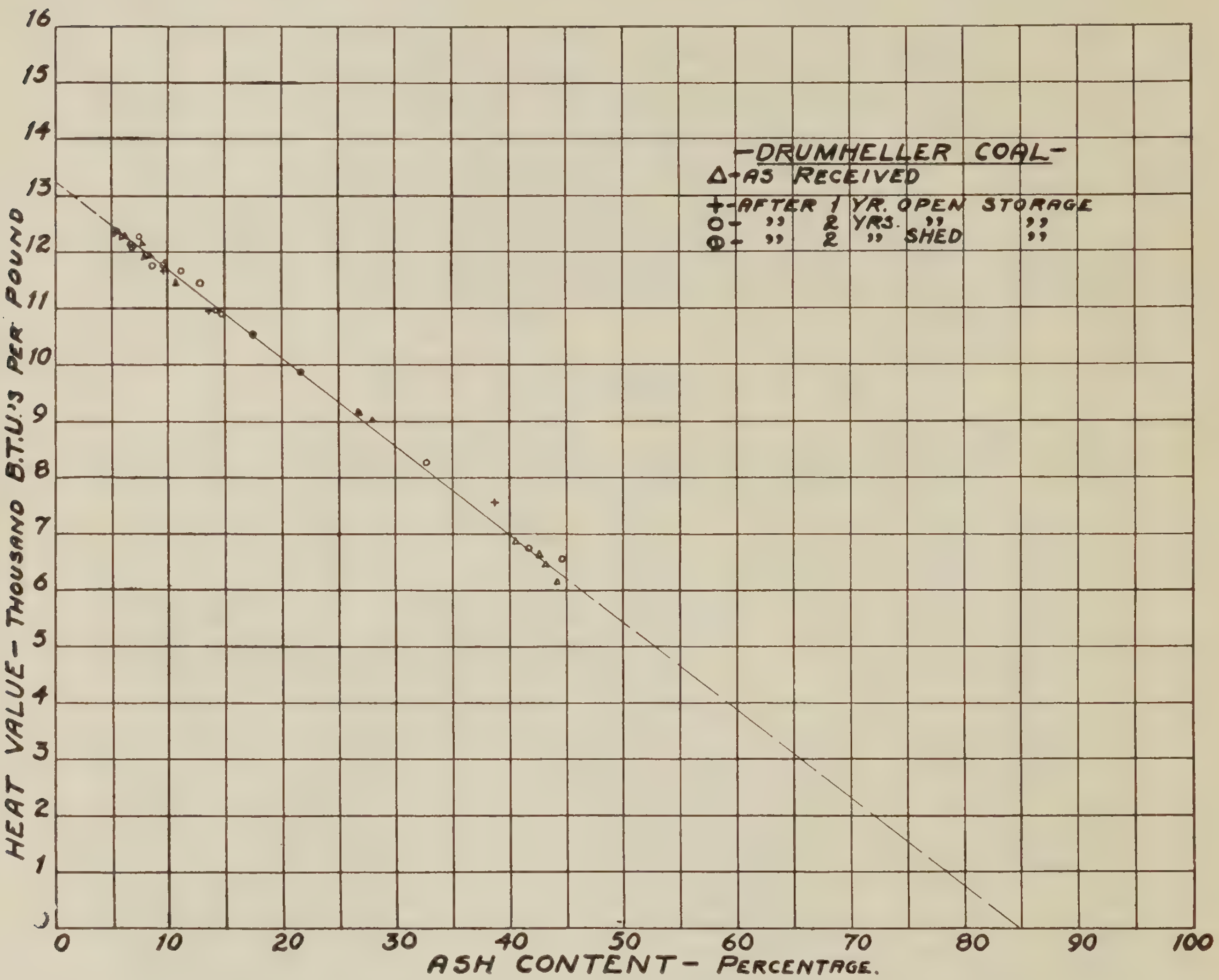

Figure 1.—Comparison Curve, Drumheller Coal, Stored.

Similar comparison curves are to be prepared for all coals now in storage.

DOMESTIC FURNACES

The following additional equipment was obtained during the year:—A Leeds and Northrup duplex recording pyrometer for recording flue temperatures; two low temperature recording thermometers in exchange for high temperature instruments previously used for flue temperatures; two Bristol recording thermometers, one for outside and one for house temperatures; two water tanks of 120 gallons capacity for use with calorimeter; one constant head water regulating tank for the same; one electric resistance heater of 20 k.w. capacity. A Uehling CO_2 machine and recorder, and a 13½ inch Wing exhauster fan were ordered, but not received in time for use during the year.

The resistance heater was a three-phase, 20 k.w. heater designed and constructed to fit inside the firebox of either the Sunshine or the Gurney furnace. This was not easy, as one was round and deep, and the other rectangular and shallow, but the difficulties were finally surmounted. Some 22 pounds of nichrome ribbon were used in its construction, wound round porcelain knobs mounted on an iron frame. It gives out some 68,000 B.T.U. per hour, which is approximately equivalent to the useful heat given out by burning Edmonton coal at the rate of 200 pounds per day. The current consumed was measured by means of an 80 ampere, 220 volt, three-phase wattmeter loaned by the City of Edmonton.

It was noted in the last annual report that the equipment on hand permitted simultaneous tests on a hot water and a hot air furnace. This was tried out a number of times early in the year with fair success; but with the installation of a calorimeter on the hot air furnace flue, with the necessary extra instruments, the work became too complicated to permit more than one furnace being tested at a time.

The extra calorimeter used on the flue was the original one described on page 23 of the Third Annual Report (Report No. 8), and as it required a separate supply of water, another water meter or some other device was necessary for its measurement. It was found that the type of water meter used was not as accurate at the slow speeds required for the calorimeters as was desired, so it was arranged to collect and weigh the water at intervals during the trial. The water for the calorimeters was piped from the main to a float valve tank on the wall. This tank was placed 11 feet above the discharges from the calorimeters to the 120 gallon receiving tanks. Each calorimeter was separately connected to the constant level tank, with needle valves on the inlet water lines to permit a fine regulation and constant flow of water for each calorimeter as desired. The discharge from each calorimeter was connected to its respective receiving tank of 120 gallons capacity. These tanks were put on brackets on the wall, high enough up to permit a weighing tank on the platform scales being placed beneath, and were each provided with a 2″ pipe and valve outlet at the bottom. An 80 gallon tank with a 2″ outlet pipe and valve was provided to catch and weigh the water from either receiving tank.

A summary of the work of testing for the year is as follows:—Gurney Furnace—11 tests totalling 491 hours with coal firing, and 7 tests totalling 56 hours with electric heating; Sunshine Furnace—5 tests totalling 266 hours, with coal firing.

Gurney Furnace

The test work during the year on this No. 908 Gurney Cottage boiler was divided into three main parts:—(1) Comparative tests with and without Robb Coal Carburetor. (2) Determination of increased efficiency made possible by change from firing three times to firing 24 times, per 24 hours. (3) Determination of furnace radiation losses and of the accuracy of the flue calorimeter by tests made with electric heating.

1.—The work of testing the Robb Coal Carburetor was completed and reported during the year. A summary of the report is given below. The Robb Coal Carburetor is an attachment to be bolted to the inside of a furnace door. It is designed to admit a regulated supply of air through the furnace door and project it in small jets over the fire. It has external ribs which absorb heat from the fire, and this heat is transmitted, with the assistance of internal baffles, to the air passing through. The object of the device is to improve combustion by forcing hot air into the mass of burning gases.

Figure 2 is a rough sectional sketch of the apparatus. This consists of a single iron casting, with a flange which is bolted to the inside of the furnace door. The ribs R, top and bottom, give a large heat absorbing surface. The air passes through an ordinary circular regulator on the outside of the furnace door and enters the casting at A. It travels in a sinuous course past the baffles B, and passes out, heated, into the fire box through the orifices at O. A No. 6B size was used, which is 6¼″ in length from A to O, and 6¼″ wide at O. There are ten rectangular orifices, 3/16″ wide. Tests were carried out with this attachment on a Gurney Cottage boiler No. 908, with a 12″ by 30″ grate. In the installation and operation, the instructions supplied with the appliance were given due attention.

Fourteen test runs were made with the Carburetor attached, and 15 duplicate tests were made with the regular furnace door damper only. The 29 tests lasted 889 hours in all. Thirteen of these tests were full quantitative runs, while the remainder were preliminary runs and special runs for a study of the combustion gases.

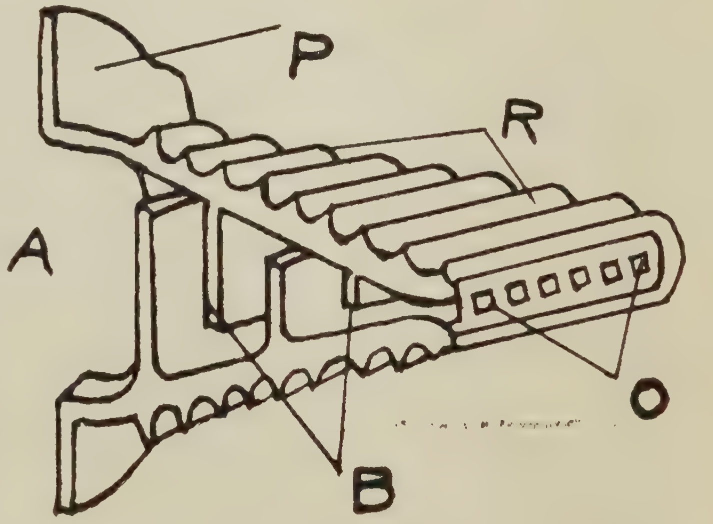

Figure 2.—Robb Coal Carburetor

All but two of the quantitative tests were carried out under running conditions which could and should be employed regularly by the ordinary house-holder. No attempt was made in these 11 tests to attain the maximum possible efficiency with the furnace by means of constant attention and adjustment, which is normally impracticable. This is in accordance with the established policy of tests carried out in this laboratory.

Two tests, however, each of 72 hours duration, were carried out with frequent firing and almost constant attention in order to ascertain what efficiency could be attained under these special conditions. In these tests a charge of 10 lbs. of coal was fired every hour. The firing was alternately to the left and the right side of the grates, and the drafts were adjusted at intervals as was found best to give a steady rate of combustion and a good flue gas. One of these tests was made with the Robb Coal Carburetor attached, and the other with the regular furnace door damper.

The tests made under ordinary conditions of household practice showed a slightly increased efficiency with the attachment. They also showed that slight changes in the firing of the coal and in the general condition of the fire may have as much effect on the flue gas composition, and therefore on the efficiency of the furnace, as changes in equipment. However, the average thermal efficiency of five tests with the Carburetor was 57%, while the average efficiency of six duplicate tests with the normal equipment was 53%. In no single case was the efficiency with the Carburetor the lesser. The flue analyses were on the whole much the same in the two series, but the average percentage of carbon monoxide was lower with the heated air jets.

These tests, therefore, were distinctly favorable to the Carburetor, but it was recognized that it was still possible that the apparent advantages were really due to some inadvertent difference in firing conditions. Two duplicate tests, each of 72 hours duration, were then carried out with frequent firing and almost constant attention, to ascertain the higher efficiency thus obtainable. These tests again showed that the efficiency of combustion was very susceptible to even small changes in treatment of the fire, damper settings, weather, etc., but once more showed the advantage to rest with the Carburetor. The principal results are summarized below.

	Robb Coal Carburetor	Regular Equipment
Efficiency ....%	64	59
Carbon dioxide in flue gas ....%	11.3	10.1
Oxygen ....%	8.5	9.8
Carbon monoxide ....%	0.3	0.3

2.—The maximum efficiency obtained with the Gurney furnace and normal equipment was 54.6% when fired three times daily as in regular household practice. When fired every hour, as described ~~on page 00~~, the efficiency was 59.3%—an increase of 4.7%. With the special equipment referred to in the previous section, a corresponding increase of 4.4% was obtained. This indicates the economy that might be gained by automatic stoking.

3.—The electric heater described on page 19 was first installed in the Gurney furnace, and was used to test out the accuracy of the flue calorimeter employed. It also allowed determinations to be made of the radiation losses. Both the furnace and calorimeter were covered with at least 1½″ of asbestocel and asbestos cement insulation. The method of conducting a test with the electric heater was as follows:—

The water flow through the furnace was adjusted to about 400 lbs. per hour, and the flue calorimeter water flow to about 180 lbs. per hour. The electric current was turned on at 7 a.m., and by 9 a.m., when the test started, the temperatures in the water outlets and the flue would be constant. The test lasted for 8 hours. The total heat generated in the furnace was calculated from the wattmeter readings. The useful heat transmitted to the water of the furnace was determined by multiplying the total amount of water passing through by its average rise in temperature. The amount of heat lost up the flue was calculated as indicated on page 22 of the Third Annual Report (Report No. 8), 1922. The radiation losses were obtained by subtracting from the total heat the sum of the useful heat and the heat lost up the flue.

A series of tests was carried out with increasing proportions of the heat going up the flue, this end being attained simply by increasing the size of draft opening, and the setting of the butterfly pipe damper. The results obtained are summarized in Table I. It was to be expected that radiation losses would be higher when the temperature of the water in the furnace was higher, also that these losses would increase as more heat was allowed to pass up the flue and thus increase radiation from the flue calorimeter. The results shown conform to these expectations. The regularity of the results is a strong indication that the flue calorimeter did correctly measure the heat passing up the flue.

TABLE I.—RADIATION LOSS WITH ELECTRIC HEATER ON GURNEY COTTAGE BOILER

Test No.	Useful Heat in Hot Water, % of input	Waste Heat Up Flue, % of input	Radiation Loss (by difference), % of input	Temp. of Water Leaving Boiler, °F.
G.E. 2	94	3	3	181
G.E. 3	88	9	3	179
G.E. 7	82	15	3	167
G.E. 4	79	15	6	195
G.E. 5	69	26	5	171
G.E. 6	62	32	6	161

At the conclusion of the above tests a survey of temperature across the calorimeter inlet and outlet was made. It showed that a heavy iron-constantan thermocouple, with a fringe of fine wire attached, placed horizontally two-thirds of the distance across the stream of gases, gave the average temperature of those gases within 1 to 2%.

Sunshine Hot-Air Furnace

This is a "Sunshine" No. 91; trade name, "Sofco." Work was chiefly confined to an examination in a new way of the data obtained in five runs of over 50 hours each. These runs were made with calorimeters on both the hot air and flue ducts.

After consultation with Prof. I. F. Morrison, the method of calculating the results of tests was modified, and a graphical method of their presentation was developed. The result was that several new points were brought out. In order to check these measurements, it was necessary to devise some means of maintaining an even temperature in the furnace over a period of at least one or two hours. An electric heater was selected as offering the most satisfactory control, and was therefore constructed as described on page 19. The results of the first tests on the air calorimeter were not as good as those obtained with the flue calorimeter, and further changes in the former were made at the end of the year in consequence. These changes are designed to ensure a far higher degree of accuracy in the measurements of the temperatures of currents of heated gases. It has long been recognized that such measurements are extremely difficult. The higher relative accuracy of the flue calorimeter was due to the smaller bulk of gases to be handled, and their higher temperature. It is considered that the electric heater has well justified its cost even in the short time that it has been in use.

SMITHY TESTS

One coal was tested during the year. The method of testing described in previous reports (Third Annual Report, 1922, p. 27; Fourth Annual Report, 1923, p. 26) was used in this test.

The coal was a sample of smithy coal from the new air washing plant of the Greenhill Mine (West Canadian Collieries, Ltd.) at Blairmore, Alta.

This plant is the first of its kind in Canada*, which adds interest to the tests.

The summary of results is as follows:—About 25 lbs. of coal were burned, and only a small amount of ash and clinker was removed in the cleaning operations. All the test operations were carried out successfully, and the coal burned with a short flame that had but slight effect on the blacksmith. It formed a good arch on coking, was quick to heat up, and wasted little coal when not in use between operations. There was no trouble from ash, clinker, or dirty fire, and all welds were easily and quickly made.

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*Vissac, G. A.: "Dry Cleaning Plant of the Greenhill Mine of the West Canadian Collieries, Ltd., Blairmore, Alta.", Bulletin, C.I.M. & M., Oct., 1924, p. 643.

RESIDENCE HEATING

Tests were made in an Edmonton residence in January and December. This is a one and one-half story, frame house, approximately 24 by 36 feet, outside dimensions. The choice of this house was a fortunate one, as at the time of the first tests it was heated with a 20-inch round pot Canadian Warmer hot air furnace. Before the later tests, this was changed to a No. 220 Eskimo combination hot-air furnace for coal or gas, with a 17″ by 22″ fire box, 18″ high, for coal burning, and four burners for use with natural gas.

The tests with the latter furnace, using both coal and gas, were not completed in 1924, so a full analysis and comparisons of the tests can not be made until the 1925 report. A summary of the results of the earlier tests are given, as these show interesting indications of the variations in fuel requirements with changing weather conditions. Coal was burned in the furnace, in a laundry jacket heater in the kitchen, and in an open grate in the living room. The chimney and hot air duct temperatures were taken by means of recording thermometers. These results may not be accurate on account of difficulties already referred to, but at least offer good comparisons. The house temperature was also taken by a recording thermometer, but the outside mean temperature was estimated from figures supplied by the weather bureau. The days for test purposes were taken from 6 a.m. to 6 a.m.

The ashes were removed daily from the furnace, and weighed; the ashes from the supplementary heaters were not weighed. A record was kept of the water evaporated in the furnace water pan.

Table II. shows the daily results in summarised form, whilst Figure 3 shows graphically the coal burned and the temperatures attained, plotted against the mean difference in temperature between the house and outside.

Table III. gives the analysis of the coal burned.

TABLE III.—ANALYSIS OF COAL IN HOUSE-HEATING TESTS OF JANUARY, 1924.

Moisture	%	15.6
Ash	%	12.2
Volatile Matter	%	27.0
Fixed Carbon	%	45.2
Calorific Value	B.T.U., per lb.	9,570

It might be stated at this time that the results with the Eskimo furnace showed that the larger fire pot enabled a far steadier house temperature to be maintained with coal firing. With natural gas firing, a steady house temperature could be easily maintained.

TABLE II.

Date	Temperatures, °F.				Temperatures, °F.			Furnace Data			Supplementary Heating, Coal		Total Coal, lbs.
January	Outside		House	Rise	Chimney Flue	Hot Air Pipe	Difference	Coal, lbs.	Ashes, lbs.	Water, lbs.	Living Room Grate, lbs.	Kitchen Stove, lbs.	
	Min.	Mean	Mean										
4	—22	13	58	45	388	124	264	219	....	12	92	52	363
5	17	32	66	34	211	108	103	141	52	12	33	17	191
6	20	24	65	41	223	117	106	110	....	13	36	37	183
7	10	13	60	47	223	108	115	154	45	9	31	18	203
8	0	4	55	51	276	111	165	165	29	14	65	37	267
9	— 6	9	62	53	323	134	189	191	19	18	94	38	323
10	10	15	62	47	232	108	124	124	16	10	31	20	175
11	6	8	59	51	281	118	163	153	18	14	68	35	256
12	3	13	59	46	259	112	147	193	18	14	63	19	275
13	12	23	63	40	221	111	110	91	17	9	62	39	192
14	— 1	4	56	52	263	109	154	163	17	12	68	18	249
15	—23	—22	53	75	384	132	252	259	39	23	93	53	405
16	—34	—30	58	88	447	151	296	321	36	25	98	41	460
17	—42	—29	56	85	436	145	291	322	44	24	68	39	429
18	—35	—21	54	75	381	128	253	288	29	20	85	54	427
19	—25	—15	61	76	417	138	279	264	24	17	110	37	411
20	— 6	21	62	41	241	105	136	139	17	11	71	38	248
21	23	24	64	43	233	109	124	115	....	10	30	18	163
22	—11	— 7	56	63	339	124	215	213	42	14	85	35	333
23	—19	—15	53	68	381	130	251	245	35	19	71	24	340
Totals	......	....	....	....	......	......	......	3,870	497	300	1,354	669	5,893
Max.	......	32	66	88	447	151	296	322	44	25	110	54	460
Min.	......	—30	53	34	211	105	103	91	16	9	30	17	163
Average	......	3	59	56	308	121	187	193	25	15	68	33	295

Distribution of Coal:—65.7% to furnace, 23% to living room grate, 11.3% to kitchen stove.

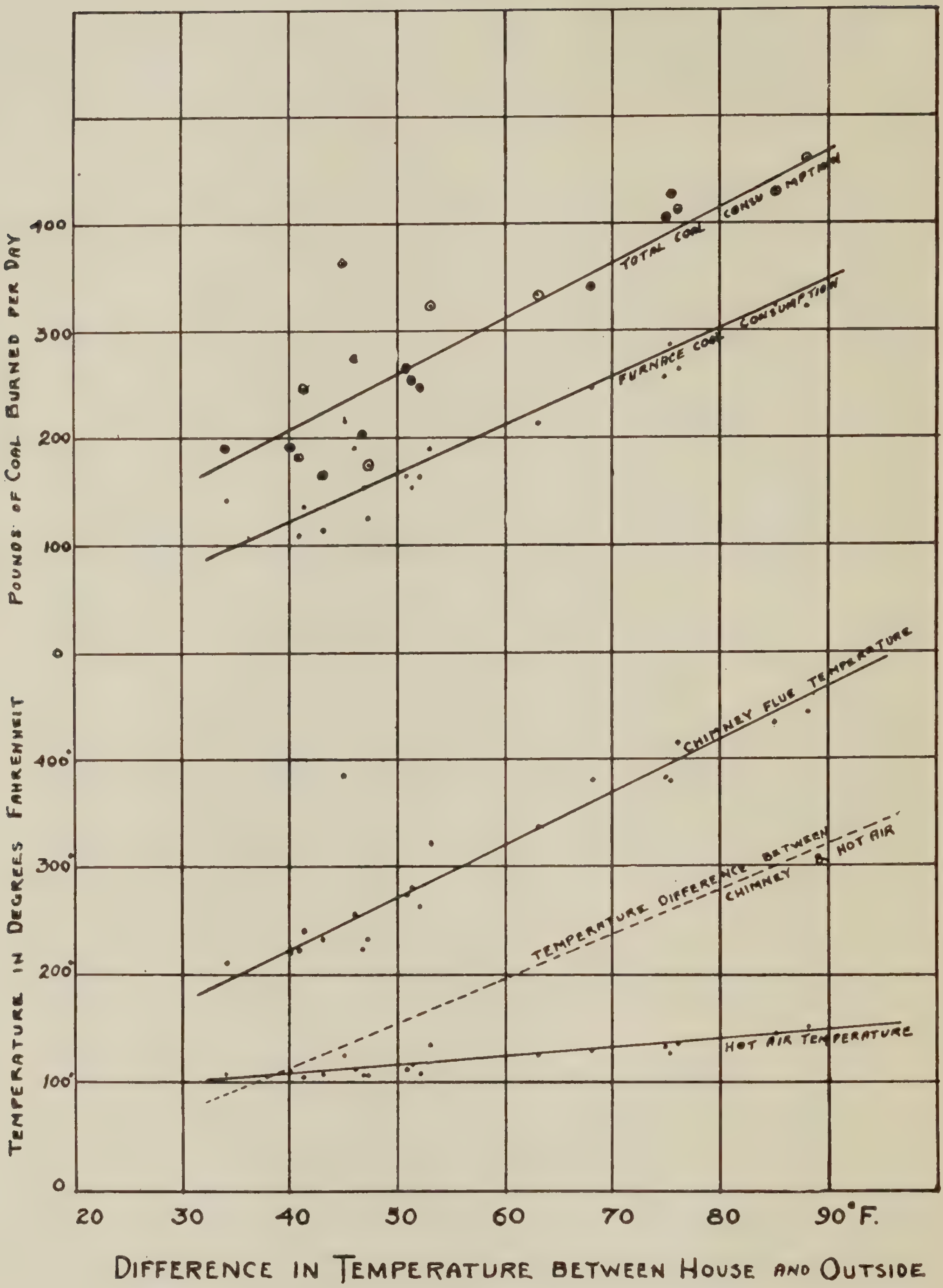

Figure 3.—House-heating Tests, January, 1924

DE-ASHING OF COAL

During the year some samples of sized bituminous coal were tested, without crushing, for ash reduction, by means of heavy solutions of calcium nitrate.

As the method of making these tests for the coarser sizes of coal had not been previously worked out, a brief description of it is given below. An apparatus was constructed capable of handling coal up to 1½″ sizes. The samples were divided into three equal parts by riffling or otherwise. One part was used with each of the two heavy solutions employed, and the third part used for ash and moisture determinations.

The sample to be treated was first weighed, then placed in a 3-gallon separation tank. This tank is of the same design as the centrifuge cups described in the Third Annual Report (1922). It is too heavy, however, for centrifuging, and the separation was effected by standing. The sample was first stirred well in the solution before the separation cone was placed in, and was then left to stand. After settling for at least four hours, the valve was screwed down tight, and the float thus sealed off from the sink. The floats and sinks were separated from the solution on a filter, washed free of the calcium nitrate, dried and weighed. The filtering was done by means of a 10″ diameter 1½-gallon capacity filter funnel specially made for the purpose. This funnel has an inner cylinder with a 30-mesh copper bottom to hold the bulk of the coal and to protect the filter paper. Drying was done first on a large sand bath, and finished by air drying in the laboratory for a day. The samples were then crushed, ground, and analyzed for ash and moisture in the usual way.

Before deciding on the specific gravities of the two solutions to be used in the tests, small scale heavy solution runs were made, and a comparison curve* obtained. Study of these data indicates the most suitable specific gravities for the solutions in order to obtain the most information regarding the de-ashing of the coal, with the minimum of work. Table IV. (next page) contains the results in condensed form of the above tests.

The results are a good indication of the amount of cleaning attainable in washing processes, but of course are better than can be expected in commercial practice. The high ash content of some of the bituminous coals of the province is a source of trouble, and one of the needs of the coal industry is a study of the possibilities of ash reduction.

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*Third Annual Report, S. & I. R. C. A., 1922, pages 29 to 31.

TABLE IV.

Size of Coal, Diameter of Circular Perforations	Sp. Gr. of Solution	Recovery, %	Ash Content, %		
			Original Coal	Washed Coal	Refuse
Through 1½″, Over ¾″	1.47	64.0	20.6	9.1	40.7
	1.575	75.2		13.1	51.2
Through ¾″, Over ½″	1.47	61.8	19.4	8.3	35.6
	1.57	81.1		12.2	44.9
Through ½″, Over ¼″	1.47	65.7	17.6	8.1	34.9
	1.565	82.4		11.8	45.0
Through ¼″	1.47	79.1	13.5	8.6	32.0
	1.56	90.7		10.7	45.1
Through 1½″, Over ¾″	1.46	62.3	29.1	5.9	63.8
	1.555	64.8		6.9	68.5
Through ¾″, Over ½″	1.46	70.6	21.7	5.9	58.4
	1.55	76.9		6.9	63.4
Through ½″, Over ¼″	1.46	72.4	18.6	6.3	53.2
	1.545	76.9		7.3	61.3
Through ¼″	1.45	84.2	12.9	7.1	45.9
	1.555	88.2		7.5	53.4

BRIQUETTING

Real progress has been made with the briquetting investigation, but the problems involved are very difficult, and the work has not yet reached the point where a comprehensive report can be made. This report supplements that of the previous year, in which the apparatus was described, and methods and results indicated.

During the year 225 batches of briquettes were made—or 384 since the commencement of the work. Classified by coals, these are: bituminous, 154; sub-bituminous, 190; and carbonized lignite, 40. Classified by binders: soft coal tar pitch, 185; hard coal tar pitch, 17; lignite tar pitch, 18; oil asphalt, 17; miscellaneous and mixed binders, 147.

The normal procedure of a test has developed to be as follows:—The coal is crushed to the desired size, and its screen analysis determined with Tyler standard screens in a shaking machine. In some cases coal of a desired screen analysis is prepared by mixing together the desired weights of each size of coal. A weighed quantity of coal (usually 8 kg.) is then placed in the steamjacketted mixer, where it is mixed and heated. The binder or binders are added, also water if desired, in weighed amounts and in the order arranged. Mixing is continued usually for two or three minutes, and the temperature raised to the required degree. The temperature is measured by a thermometer immersed in oil in a guard tube which projects into the mass mixed. The charge is then dumped into a suitable box, and hand-fed to the press at the rate required to make a standard-sized briquette each stroke. Hand-feeding the press direct from the mixer, rather than through the fluxer with its mechanical discharge, has been found to enable a more accurate determination of the temperature at the press, and to give a more uniform size of briquette. It was found, also, that the abrasion of the binder-coated particles in the fluxer exposed fresh and uncoated surfaces which materially reduced the quality of the briquette. Records are kept of the mixture made, order of mixing, time of mixing, temperature at each stage, and particularly the temperature of the mix as it goes to the press, also of any special points observed during the mixing and the behaviour of the mix in the press. Immediately after pressing a small sample of the briquettes is taken and weighed, and the moisture lost during air-drying and the moisture retained after air-drying determined. When the bulk of the briquettes have air-dried to normal conditions (one week usually suffices for this) samples are tested in the rattler machine for abrasion loss, in a furnace to determine firing qualities, and in the laboratory to determine real and apparent specific gravity and also porosity. In some cases a sample is exposed to the weather for a few months and then tested in the rattler for comparison with the rattler results on the original briquettes. Briquettes are regarded as satisfactory when the tests indicate that they can be handled and shipped without serious abrasion losses, will burn well in the fire without falling to pieces, and can be stored exposed to the weather without notable deterioration.

During the year the 10 h.p. motor was replaced by a 15 h.p. motor, and a new and stronger spring was used with the press. This spring had been calibrated in the Civil Engineering laboratories by Prof. R. S. L. Wilson. These changes enabled slightly higher pressures to be used in briquetting. Partly due to the higher pressures employed and partly to improved technique, many batches of briquettes were made during the year which showed less than 10% rattler loss. One of these was made with lignite pitch, a few were made with asphalt, and the rest with mixed binders. A briquette, otherwise satisfactory, that does not lose more than 20% in the rattler test is regarded as strong enough to be handled and shipped.

A large number of mixed binders were tested during the year. In earlier work, mixtures of pitch and asphalt appeared to be very unsatisfactory, but good briquettes have now been made with several different mixtures of these. Mixing waterglass with pitch makes the latter emulsify easily with water, and forms a tough, leathery product which was expected to make a good binder. Actually, addition of waterglass to any type of binder lowered the qualities of the briquette produced, probably because the binder then does not adhere well to the coal. Bentonite and other clays are similar to waterglass in this respect.

Straw, sawdust, flour, starch and oatmeal were all tried as binders, and were all found to have good binding properties. The two first required to be converted to a jelly-like mass before use. This can be done in several ways, but most readily by cooking with a dilute solution of caustic soda in an autoclave and then pulping in a ball mill. The fibres of straw or wood, as such, appear to be valueless; as the more completely these are pulped, the better the result. The temperature of cooking can be varied over a considerable range, but 180°C. gives rapid treatment without charring the material. The flour, starch, and oatmeal can be converted into paste by water and heat during the mixing process. These jellies and pastes are not satisfactory alone, as they are not waterproof, but if pitch or asphalt is added, they make strong briquettes which are less smoky in the fire than briquettes made with pitch or asphalt alone. This type of briquette, however, has not the weather-resisting qualities of the regular pitch or asphalt briquette.

Sulphite pitch was tried alone and in mixtures, but as this binder is not as yet available for use in Alberta at a reasonable cost, only a few trial batches were made.

Considerable work has been done with regard to the effect of water in the mixture when briquetting, and some very interesting results obtained. Good briquettes can be made without any water, but a serious difficulty is the tendency of a dry mixture to adhere to the plungers of the press. The best results were obtained with sub-bituminous coal when the mixture going to the press contained about 5% of moisture; and it is immaterial whether this water is added before or after the binder, except with regard to temperature control. The hotter the batch during the mixing stage, the more fluid the binder, and the less time and power are required to give thorough mixing. On the other hand, if there is to be free water in the batch at the press, the temperature there can not exceed 100°C. A simple and satisfactory method appears to be to mix at a temperature slightly above 100°C., and then add enough water to give 5% in the mixture as it goes to the press, and to cool the mixture to about 95°C. It should be stated, however, that many contradictory results have been noted from time to time, and the effect of water in briquetting is receiving further study.

Sub-bituminous coal can be briquetted to give a strong briquette, but such briquettes do not stand up well when they are thrown into a hot fire. The addition of a small amount of finely-ground coking bituminous coal markedly improves their quality in this respect.

Progress has been made with the study of the physical properties of the binders. Much time, however, has been spent in devising suitable tests and constructing the necessary apparatus, so that the work is not yet ready to be reported.

Work in 1925 prior to going to the press has included many tests with asphalt as binder. Excellent briquettes have been made with sub-bituminous coal with the addition of 10% of bituminous coal and 6% or less of asphalt. There do not now appear to be any serious technical obstacles to prevent briquetting sub-bituminous coal on a commercial scale, whilst the economic possibilities of such an undertaking appear very hopeful.

Special attention was given during the year to sub-bituminous coal for two reasons:—First, because little was known about the behaviour of such coal when briquetted; and second, because the only fine coals in the province which can not be marketed at present without treatment are of this grade.

GEOLOGICAL INVESTIGATIONS DURING 1924

By John A. Allan

INTRODUCTION

During the first five months of the year the data obtained in the field were compiled, and a geological map prepared. Considerable time was spent editing and distributing the 1923 report and the accompanying map. This is Report No. 9, entitled "Geology along the Blackstone, Brazeau, and Pembina Rivers in the Foothills Belt, Alberta."

The writer was assisted in the office by Dr. R. L. Rutherford and Miss Marjorie Walker. During the last three months of the year Dr. P. S. Warren rendered valuable assistance by determining the paleontological material collected during the field seasons of 1923 and 1924. L. S. Russell gave assistance in the drafting room.

Correspondence increased over the previous year. The writer received and sent out 1,299 letters, many of which dealt with more or less extensive information on various mineral deposits, especially coal, oil, gas, clay, iron, phosphate, gypsum, placer gold, and platinum.

Over one hundred specimens were received that required examination—in some cases tests that required several hours. All samples that required chemical analyses or assays were forwarded to Mr. J. A. Kelso, Director of Industrial Laboratories, at the University of Alberta. When clays were sent in that required extensive fire tests, the senders were recommended to forward samples to the Mines Branch, Ottawa, because the Industrial Research Laboratories were not yet equipped with apparatus for detailed testing of clays.

Two field parties were directed by the writer, and over 7,000 square miles were surveyed geologically. One party, with Dr. R. L. Rutherford in charge, continued the foothills survey started in 1922. The second party, with J. O. G. Sanderson in charge, made an areal survey on the plains along the Red Deer valley. This was a continuation of the survey of the Drumheller coal basin made in 1921. A summary of the results obtained in these field surveys is given below.

The visit of the British Association for the Advancement of Science to Edmonton in August necessitated some preparation on the part of the writer, as a technical session of the Geology section was held at the University of Alberta. The writer considered the visit of scientists of sufficient importance to have Dr. Rutherford and Mr. Sanderson attend the session in Edmonton.

One week was spent in south-eastern and southern Alberta with the Soils Survey party, correlating soil types with the surface geology. A short outline of this work is given in another part of this report. In addition to visiting the survey parties in the field, the writer investigated alum deposits on Smoky river and placer gold on Athabaska river. The results obtained are summarized below.

The writer spent some time during the year on the extension of the geological classification of coal in Alberta by areas, and on the geological map of Alberta which is being prepared.

At the request of the Royal Canadian Air Force, the writer made a flight with Flying Officer A. A. Carter on October 18th from Eckville west towards the Saskatchewan river north of Rocky Mountain House. The object of this flight was to determine if it were possible for a geologist to distinguish between rock outcrops and unconsolidated sand or gravel, from an aeroplane at an altitude of about 2,500 feet. The observations proved that in most cases this distinction could be made. The advantage of the aeroplane in determining the geographical position of rock outcrops where rock exposures are few cannot be doubted. Aerial photographs are of very great service to the geologist in facilitating the ground survey work, and much time can be saved by having the country photographed from the aeroplane prior to making the geological survey.

The writer wishes to extend his thanks to officials of the Royal Canadian Air Force for the accommodation and consideration given him in making these experimental observations.

The writer wishes to record the fact that as a result of a request to the Hon. Charles Stewart, Minister of the Interior, aeroplane photographs have been taken by the Royal Canadian Air Force in June, 1925, along the North Saskatchewan River upstream from Edmonton, for the use of the Alberta Geological Survey in surveying the river section in 1925 between Rocky Mountain House and Edmonton.

GEOLOGICAL SURVEY OF FOOTHILLS BELT BETWEEN McLEOD AND ATHABASKA RIVERS

During the past three years field geological investigations have been carried on in the foothills of central Alberta. Up to date about 3,000 miles have been mapped geologically, and a belt from North Saskatchewan river to Athabaska river has been surveyed. The distributions of the coal-bearing formations and associated formations have been mapped. The positions of the coal horizons and the structure within this belt have been determined. On account of the scarcity of outcrops, and the heavy mantle of vegetation, it is a difficult part of the province to survey geologically. Much credit is due to Dr. R. L. Rutherford, who has had charge of the field surveys, for the results he has been able to obtain under such adverse conditions. It has only been by mapping and correlating the exposures along the drainage courses, both small and large, that it has been possible to connect up the structure in the interstream areas.

Report No. 6 deals largely with the Saunders Creek coal area and part of the Nordegg area; Report No. 9 with the remainder of the Nordegg area and southern part of the Coalspur coal area; and Report No. 11 deals with the results obtained in the field by Dr. Rutherford in 1924, and includes part of the Coalspur coal area and that part of Prairie Creek coal area south of Athabaska river. The area covered by Report No. 11 lies between McLeod and Athabaska rivers in the foothills, and comprises approximately 600 square miles. The report is entitled "Geology of the Foothills Belt between McLeod and Athabaska Rivers, Alberta." The map accompanying the report (Map No. 7) is printed in eight colours on a scale of one inch to two miles. The topography of the area is indicated by contour lines drawn on one hundred foot intervals. The topography of a part of this area has been taken from the Cadomin topographical sheet published by the Geological Survey of Canada, but the remaining topography is based on compass and aneroid control.

The geological formations of Upper and Lower Cretaceous age and the Jurrassic are differentiated in colour, but the older rocks have not been subdivided in the discussion of this area.

The information on which this report is based was obtained in the field between May 28th and September 13th, 1924. Dr. R. L. Rutherford was in charge of the party, and he was assisted by L. Telfer. The other members of this party were G. Haworth and H. Scott. The writer spent a short time with the party at the close of the field season.

The wooded character of the foothills belt and the scarcity of exposures make correlation of formations, and especially of coal seams, difficult.

The identification of geological horizons, the correlation and structure of coal seams and associated sediments, have been made largely on lithology, as is commonly the practice; but in Upper Cretaceous formations, such as those which occur in the foothills of Alberta, where there are thousands of feet of beds of brackish and fresh water origin of similar lithological composition, correlation by lithology alone is often unsatisfactory. Lithological correlation is especially difficult in such an area as this because of the thickening and thinning of the sediments, with new members appearing and others disappearing in different locations within the area. Rutherford has determined the structure in the foothills from rock exposures along the main and tributary streams. Horizon markers have been used in carrying along the correlation in the interstream areas. When the petrology of the Upper Cretaceous sediments in Alberta is more extensively studied, the writer is convinced that this information will be valuable in identification and correlation of horizons in the coal-bearing formations. Close attention is given in the field to the occurrence of fossils, both animals and plants. It is already apparent that paleontological evidence will be of value in correlation. All fossil material collected in the field has been determined by Dr. P. S. Warren, Associate Professor of Geology at the University of Alberta.

The structure is typical of the foothills, consisting of open and broken anticlines, synclines and monoclines, more highly contorted towards the southwest, and less disturbed to the northeast. The entire map area is within the foothills, with the eastern edge of the area mapped representing closely the eastern edge of the foothills.

In the Kootenay formation the main structure of the coal seams has been determined in the vicinity of Cadomin and Luscar. Coal seams in this formation have been prospected on the north slope of Folding Mountain in the "Drinnan Mine." The Blue Diamond mine at Brule is in the continuation of this belt of Kootenay rocks on the west side of Brule lake.

At Cadomin there appears to be one seam that is repeated three times by folding. The thickness of this seam is 22 to 25 feet, but folding and faulting of the strata cause local variations in the thickness of the seam mined.

The Luscar mines are less than five miles northwest of Cadomin, but the structure is quite different. Four coal seams have been recorded at the Luscar mine: 42, 49, 36, and 28 feet in thickness, respectively. It is possible that some of these seams represent a duplication by faulting and folding.

The coal seams at Luscar are believed to occur on the eastern limb of a syncline, which is faulted against Colorado strata to the east.

Details of structure were not obtained by Rutherford from the mines working at Cadomin and Luscar, because these data were being compiled by Dr. B. R. MacKay for the Federal Geological Survey.

In 1924 the Cadomin and Luscar Collieries produced about 220,000 tons of coal. The quality of the coal is bituminous, with approximately 3% moisture as mined, 25% volatile matter in the former, and 20% in the latter.

At the Drinnan prospects on Folding mountain, four coal seams have been recorded: 12, 10, 12, and 5 feet in thickness, respectively. It is known that coal seams occur in the Kootenay within the twenty miles between Luscar and the north end of Folding mountain, and the structural conditions in this area are discussed by Dr. Rutherford in Report No. 11.

Saunders Coal

An attempt has been made to carry through from Coalspur and McLeod river to the Athabaska the correlation of the coal horizons in the Saunders formation, as determined between North Saskatchewan river and Coalspur, and described in Reports Nos. 6 and 9. In the vicinity of Brazeau river, five coal horizons have been determined in the Saunders formation, overlying marine Colorado strata. These coal horizons are distributed throughout approximately 14,000 feet of strata. In the Saunders Creek basin only one coal horizon occurs, which is about 250 feet thick.*

Field investigations by Rutherford have proved that the number of coal horizons decrease northwest from Coalspur, and, furthermore, there appears to be a rapid decrease in the thickness of the coal seams and in the number of coal seams from the northeast to southwest across the area represented on Map No. 7. On McLeod river, in township 47, range 23, the lower 5,000 feet of strata in the Saunders formation are barren of coal seams. Along Athabaska river, west of the mouth of Prairie creek, Rutherford states: "There are no seams of commercial thickness or quality in the lower 10,000 feet of the Saunders formation."

There are three companies mining coal in the area from the Saunders formation, namely, Bryan, Balkan, and Saunders Ridge (formerly the McLeod River Hard Coal) at Mercoal. The production from these three mines in 1924 amounted to approximately 46,000 tons. The Yellowhead Coal Co. mines at Coalspur have been abandoned since 1923. The coal seam mined at these four localities has been correlated as the same seam, but the dip varies with the structure. At Balkan and Bryan mines the strata dip 38 degrees to the northeast. At Coalspur the dip is 55 degrees to the southwest, and the strata are on the west side of a broken anticline. Between Coalspur and Mercoal the structure is synclinal, and in Saunders Ridge mine the dip is 34 degrees to the northeast.

The quality of the coal is sub-bituminous, with moisture as mined 8 to 11%, and volatile matter 34 to 36%.

There are two seams in this part of the area, but most of the mining is done in No. 2 seam.

The coal seams worked at the Balkan mine and at Mercoal have been traced through to McLeod river, but those seams mined at Coalspur disappear by faulting in the intervening area between Coalspur and McLeod river.

Coal seams outcropping at the mouth of Teepee creek on Gregg river have been correlated with those at Mercoal.

In the south slope of Athabaska valley, rock outcrops are few, vegetation is dense, and unconsolidated sand and gravel deposits are wide-spread; so that if there are commercial coal seams, it will be necessary to locate these by prospecting and drilling. There are seams of coal on Prairie creek and also on Happy creek. There may be other seams east of these, as the structure at the Balkan and Bryan mines extends through to the Athabaska, and more extensive prospecting may prove the occurrence of coal seams near Athabaska river.

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*Allan, J. A.: Geology of Alberta Coal. Trans. Can. Inst. Min. & Met., Vol. 28 (1925), p. 398.

The top of the Saunders formation has not yet been determined, but the field survey in 1925 will extend the correlation of the strata in the foothills belt eastward to the Evansburg coal basin in the Pembina coal area, and later with the Edmonton coal area.

CARBON, BIG VALLEY, AND ARDLEY COAL AREAS SURVEY

A second geological survey party was directed by the writer in 1924 in central Alberta, extending the survey of the Drumheller coal area which was made in 1921, and described in detail in Report No. 4 of the Scientific & Industrial Research Council of Alberta.

The field work was carried out by J. O. G. Sanderson, who had with him E. Jones and E. Davis as assistants. Approximately 6,900 square miles of territory were mapped geologically by Mr. Sanderson. This area includes the greater part of the Rosebud and Red Deer sectional maps issued by the Topographical Survey of Canada. It was only possible to traverse such a large area in the short field season by using automobile transportation.

The detailed report on this survey is now being prepared by the writer, and will be published as Report No. 13. The area mapped includes the mining centres of Carbon, Rosebud, Threehills, Trochu, Big Valley, Ardley and Nevis.

The objects of this survey were to correlate the coal seams that are mined at the various centres within the area, to complete the correlation of the Edmonton formation, and to determine the relative positions of the various coal seams. The Red Deer river, its tributary streams and coulees, afford a continuous section throughout the entire thickness of the Edmonton formation. The top of this formation is exposed at the water level at elevation 2,595 feet on Red Deer river about 10 miles west of Ardley in section 2, township 38, range 25, west of the 4th Meridian; while the base of the Edmonton formation is exposed at river level near the mouth of Willow creek, about five miles downstream from Rosedale in section 12, township 28, range 19, west of the 4th Meridian, at an elevation of 2,126 feet.

In the survey of the Drumheller coal area, the coal seams were correlated from the base up to Seam 10. Sanderson was able to correlate the coal seams from Seam 10 to the top of the formation at Ardley, where the uppermost seam (Seam 14) is mined.

The complete section of the Edmonton horizon in this part of Alberta is 1,224 feet in thickness, with fourteen coal seams, having an aggregate thickness of approximately 62 feet. Eight of these coal seams are mined today, with an aggregate thickness of 52 feet of coal. This does not mean that wherever these coal seams occur in this area there will be a uniform thickness of coal of commercial quality, because the lateral variation in quality and thickness in these coal seams is very great, and all parts of any particular seam are not of equal market value.

The complete section of the Edmonton formation exposed along the Red Deer valley between Ardley and Willow creek, and measured by Rutherford, Sanderson, and the writer is as follows:—

Section of Edmonton Formation in Red Deer Valley

FEET	DESCRIPTION
	Contact overlain disconformably by Paskapoo
60	Sandstone and shale
20	No. 14 seam (Ardley)
50	Rock
3	No. 13 seam (Nevis)
170	Rock
1	Volcanic tuff
50	Rock
5	No. 12 seam (Thompson)
90	Rock
6	No. 11 seam (Carbon) (Paton)
155	Rock
3	Corbicula zone
20	Rock
3	Ostrea zone
85	Rock
	Ornithominus zone, 110 *feet above No.* 9
2	No. 10 seam (Marker seam)
60	Rock
1	No. 9 seam
15	Rock
2	No. 8 seam
100	Rock
4	No. 7 seam
25	Rock
2	No. 6 seam
70	Rock
5	No. 5 seam
15	Rock
1	No. 4 seam
10	Rock
1	No. 3 seam
10	Rock
3	No. 2 seam
30	Rock
6	No. 1 seam
40	Rock
1	No. 0 seam
100	Rock
	Bearpaw shales at base
1,224	Total thickness of the Edmonton Formation.

In Report No. 5, on the "Geology of the Drumheller Coal Basin," the lower contact of the Edmonton was shown to be irregular on the underlying Bearpaw shales, with fingers of the shale occurring in the basal Edmonton strata.

The surface of the Edmonton formation has been determined by Mr. Sanderson as an erosional plain, with the younger Paskapoo strata lying disconformably upon the Edmonton erosion surface.

This observation on the relation of these two formations is a discovery that is of very great geological significance, and is additional information on the stratigraphy of Alberta. The disconformity means that for a time the uppermost sediments in the Edmonton period of deposition formed a land surface which later became submerged, and on which the younger Paskapoo sediments were deposited. The maximum amount of disconformity between these two formations is represented by about 450 feet of strata, according to observations by Sanderson.

The field investigation in 1924 in the coal areas mentioned above has proved the following points with reference to the coal seams:—

1. The coal seam mined in the vicinity of Carbon is No. 11, and is a higher seam than any of those mined in the Drumheller coal area.

2. The *Carbon seam* is also mined on Rosebud creek, six miles north of Rockyford; in section 33, township 27, range 21, six miles northwest of Benyon, at Standard; and up Red Deer valley, where it is known as the *Paton seam* in township 37.

3. Seam 12 (*Thompson seam*) is mined on the banks of Red Deer river in townships 35 and 36.

4. Seam 13 (*Nevis seam*) is mined about one mile northwest of Nevis, in township 39, range 22. This seam is 45 feet below the *Ardley seam.*

5. Seam 14 (*Ardley seam*, or *Big seam*) occurs close to the top of the Edmonton formation, and is mined in the vicinity of Ardley, Trochu, Threehills, Rowley, five miles west of Scollard, and at Big Valley.

6. The Ardley seam corresponds in stratigraphic position to the Pembina seam at Evansburg, and to the Wabamun seam.

7. Two fossil horizons have been determined in the Edmonton formation, and these will undoubtedly be of assistance in the correlation of coal seams in other coal areas. These horizon markers are designed by the principal fossil that occurs: namely, the *Corbicula* zone and the *Ostrea* zone. These zones occur 155 feet and 178 feet respectively below the Carbon seam (Seam 11).

8. Another horizon that will probably be more continuous than the fossil zones, and therefore of great correlation value, is a bed of volcanic tuff about one foot in thickness that has been determined and mapped by Sanderson. This volcanic tuff bed occurs about 50 feet above Seam 12 (Thompson seam). A detailed microscopical and chemical examination of this tuff is being made by Sanderson, and the results obtained will be published later.

9. The eastern boundary of the Paskapoo formation between townships 25 and 40 has been mapped as far east as and including Hand hills.

10. The Edmonton-Paskapoo contact, and the younger Tertiary rocks of Oligocene age capping the Hand hills have also been determined. The coal seams in the vicinity of this residual outlier and also in the vicinity of Sheerness have been examined and correlated with the coal seams along Red Deer valley.

SOIL DISTRIBUTION AND ITS RELATION TO SURFICIAL DEPOSITS IN SOUTHEASTERN ALBERTA

A soils survey of Alberta is being carried out under the direction of Dr. F. W. Wyatt, Professor of Soils at the University of Alberta. During the past two years the writer has spent a short time with Dr. Wyatt, making a general survey of the surface geology of certain parts of Alberta, and noting particularly the influence of geology on soil distribution. Much of the area included in the Macleod, Lethbridge, Medicine Hat and Rainy Hills sectional topographical sheets has been examined. A short geological appendix will be included with each of the soils reports prepared on this area.

In 1924 the writer spent about a week with the soils survey party, and a traverse was made down the east side of the province from Oyen on the Canadian National Railway in township 27, through Acadia valley, Empress, Medicine Hat, and Cypress Hills, to Comrey; then west up the Milk River valley to Coutts, via Milk River ridge to Cardston, and to Waterton lakes. The broad surface geology features were noted, but these will not be discussed in this report. Although the prime object of this survey was to observe the influence of the geology on soil distribution, yet data of a broader geological character were obtained when time permitted. Additional information was obtained on clay deposits, coal seams, and on the general stratigraphy of south-eastern Alberta.

Cypress hills form the most pronounced topographical feature in southeastern Alberta. The western end of these hills is in Alberta, but the greater part lies in Saskatchewan. The hills rise about 500 feet above the plains at Medicine Hat, and represent a residual outlier on the plains. There are three pronounced residual hills in Alberta, the tops of which represent the former level of the surrounding plains. These are Cypress hills in southeastern Alberta, Hand hills east of Drumheller, and the Swan hills south of Lesser Slave lake. Each of these prominences is important geologically.

The plains of southeastern Alberta at one time were at the same elevation as the top of Cypress hills. The hills are capped by Miocene loose conglomerate, the youngest consolidated rock in Alberta. The top of these hills is as flat as any part of the surrounding plains. There is no evidence that the top of the Cypress hills was ever covered by the ice sheet, even during its maximum extension.

Clays exposed on the slopes of these hills at the west end appear to be of high quality. A further investigation of these clays is warranted.

The Milk River ridge between Coutts and Cardston is another prominent topographical feature, but this ridge is due to structural features rather than to erosion.

On this traverse, a visit was made to Comrey to determine the horizon of the coal mined in township 2, range 6, west of the 4th Meridian. This coal seam is in the upper part of the Belly River series, corresponding in age to the coal at Taber. The quality of the coal is lignitic, influenced somewhat by the Sweetgrass Buttes that extend from township 1, range 10, south into Montana. The "badlands" along Milk River valley, and north of Comrey, are formed in the Belly River rock, and form a topography similar to the badlands along Red Deer valley in the same formation.

A geological report has been prepared by the writer on "The Relation of the Geology to the Soils in the Macleod Sheet." The report will form an appendix to the soils survey report on that topographical sheet by Dr. Wyatt and his associates. A few notes are also included on the source of the water supply in this part of Alberta.

Most soils have been derived from the disintegration of older rocks. There is therefore a close relationship between the soils in any area and the geology in or close to that area. In the Macleod sheet there are four types of unconsolidated surface deposits:—

1. Residual deposits, formed from the underlying rocks by chemical and mechanical processes of weathering.

2. Transported deposits of alluvial, lacustrine, and wind origin. These deposits are found along the present river courses or along old drainage courses.

3. Glacial moraine, consisting of unsorted gravel and sand in the form of *till* or *boulder clay* left by retreating ice sheets.

4. Re-sorted glacial deposits that occur along glacial drainage courses or in lakes and ponds at or close to the front of the ice.

The distribution of these different types of surficial deposits in the Macleod sheet are discussed in the report appended to the Soils report.

ALUMINIUM SULPHATE

The presence of alum salts in the banks of Smoky river has been known for several years. Samples received for analysis have been recorded in Report No. 2 (1920), page 126, and in Report No. 5 (1922), page 39. The writer made a brief examination of a deposit near the mouth of Little Smoky river in 1924.

Little Smoky river joins Smoky or Big Smoky river in township 77, range 24, west of the 5th Meridian. The valleys of these two rivers are cut 500 to 600 feet below the adjacent plateau. The elevation at the junction of these two rivers is approximately 1,275 feet above sea level, and the plateau has an altitude of about 1,850 feet. Extensive slumping of the soft rocks has occurred along the sides of the valleys. Slump blocks half a mile or more in length are common. The rocks outcropping along the sides of these valleys near the junction of the Smoky and Little Smoky have been determined by Dr. F. H. McLearn of the Dominion geological survey, as the *Smoky River formation*, the lower part of which is elsewhere correlated with the Colorado group of Upper Cretaceous age. It is the "lower shale" member of the Smoky River formation that occurs in the slump banks about the mouth of Little Smoky river. This member consists of clay shales and sandy clays.

At many points along the valley sides, the shale surface has a thin white incrustation of aluminium sulphate. In some places a concentration of this alum salt forms a heavy white deposit, where the salt has been leached from the shales. At a few places a white deposit of sulphate of aluminium covers the side of the valley, and has a depth of at least two feet. Usually the alum salt incrusts and cements angular fragments of shale, and sometimes even waterworn pebbles, so that the whole rock is a breccia. At no place was more than one or two inches of pure sulphate observed between the angular fragments. This means that although the white incrustation is extensive and indicates a large deposit, yet the amount of pure aluminium sulphate is relatively very small and unimportant economically. The shale fragments enclosed in the breccia also contain aluminium sulphate, but the percentage is very small as compared with the incrustation.

The deposit of aluminium sulphate has been derived from the "lower shale" member of the Smoky formation by leaching of the contained salts in the shale. The waters are all of meteoric (surface) origin. These sulphates are undoubtedly derived from the oxidation of the shales and overlying sandstones containing sulphides of iron in the form of pyrite and marcasite. Wherever there is a seepage along the sides of the valley, there is always evidence of aluminium sulphate, and often the incrustation is quite extensive. The largest deposit observed occurs close to the mouth of Little Smoky, but even here the amount of pure aluminium sulphate is quite insufficient to class it as a commercial deposit.

The crystallography of this mineral has not yet been completed, so it is not yet known which alum mineral is present. The following analyses indicate the range in composition of the deposit:—

Insoluble in water	%	4.75	3.02
Analysis of water soluble:—			
Sulphuric anhydride (SO_3)	%	67.18	73.56
Alumina (Al_20_3)	%	16.21	10.04
Iron oxide (Fe_20_2)	%	6.19	4.16
Lime (CaO)	%	......	......
Magnesia (Mg0)	%	8.24	9.74
Potash (K_20)	%	2.06	2.32

The occurrence of aluminium sulphate in Alberta is of importance. Although this occurrence as observed is small as to quantity, the possibilities of larger and workable deposits in this part of Alberta are promising.

Alum is used chiefly in tanning skins and in sizing paper, but also in dye manufacture, water and sewage clarification. In May, 1925, the price of aluminium sulphate on the New York market was quoted at $1.40 to $1.45 per cwt.

Placer Gold on Athabaska River

A reported enrichment of gold placers on Athabaska river near Smith was examined by the writer. The locality investigated is about ten miles south of Smith, and upstream on the west bank of Athabaska river in township 70, range 1, west of the 5th Meridian. A small washing plant had been installed, and colors were obtained from any of the sands from the water line to the top of the bank, about 100 feet above the river level. This wide distribution of gold was found to be due to slumping of the upper gravels, where the values appear to be higher.

At the point where the examination was made, the gravel, sand and clay carrying gold values occur within about five or seven feet of deposits, 90 feet above water level. These deposits are of lake origin, and were formed when the early drainage of the Athabaska was dammed up, and a lake resulted. The sands were panned by the writer at different levels down to the water line farther down stream, but few colors were observed.

Samples taken from the upper five feet were panned on the ground by the writer. The weight of the sand was determined. The gold values averaged $1.30 per cubic yard of 3,000 pounds. This gold content represents about one cent per pan of sand. The fineness of the gold was not determined accurately, but it is represented approximately by 300 colors to the cent. Another sample taken from the same bed of gravel, but 75 feet down stream, contained values of 61.4 cents per cubic yard, or approximately half of one cent per pan. The following assay results were obtained from four samples panned on the ground, and assayed by J. A. Kelso, Industrial Laboratories, University of Alberta:—

Sample No.	**Location Sampled**	**Value per cubic yard of 3,000 lbs.**	**Value per pan**
1	Upper 5 ft. in west bank, 90′ above water level	$1.30	1.0c
2	6′ shaft on top of bank, about 10′ higher than No. 1	65.4c	0.5c
3	Upper 3′ in the shaft	40.2c	0.3c
4	Same horizon as No. 1, and 75′ downstream	61.4c	0.5c

These analyses indicate that there are fair values in the gravels at the top of the escarpment, and 90 feet above the river level. This location makes it difficult to get water on the richest gravels for prospecting purposes. The various tests made with the pan indicate that the best values occur within a thin bed of gravel about 5 feet thick. Further prospecting of these gravels is necessary before any more detailed conclusion can be given.

Coal Areas of Alberta

In the Annual Report of Council for 1923 a map of Alberta was included on which the writer had outlined 36 coal areas. These coal areas were defined with reference to the geological formations in which the coal seams occur, and the extent of each coal area was defined by the chemical and geological data available at the date of publication. The coal areas as outlined on this map are used for the chemical classification of coal by the Industrial Research Department in Edmonton, and also by the Mines Branch, Ottawa.

In 1924 these coal areas were also accepted by the Alberta Mines Branch as denoting coal inspection areas. This means that in the future all mining statistics compiled by the Alberta Mines Branch, as well as chemical and geological data, will be given according to this Alberta Coal Areas map.

On the original map (No. 6) the 36 coal areas were divided according to the three coal-bearing formations. Ten of these areas indicate the distribution of the *Kootenay* formations, where the contained coal seams are accessible to mining operations; fourteen, the *Belly River* or *Saunders;* and the other 12 areas, the *Edmonton.*

When these coal areas were accepted as mine inspection areas, it was necessary to increase their number in order to include all points where coal was being mined. Six were added to the Belly River or Saunders list, and the Brooks coal area was divided between townships 18 and 19. The name "Steveville" was given to the northern part of the original Brooks area. These new areas are defined as follows:—

Coal Area	Townships	Ranges	Meridian
Sexsmith	69 to 78	2 to 4	W. of 6th
	72 to 78	5 & 6	
Valhalla	72 to 78	7 to 13	6th
Steveville	20 to 26	9 to 16	4th
Empress	17 to 23	1 to 8	4th
Wainwright	44 to 47	5 to 10	4th
Pakan	54 to 60	9 to 20	4th
Rochester	58 to 63	21 to 25	4th

The northern limit of the Redcliffe area has been moved 3 miles north to the boundary between townships 16 and 17.

Two additional coal areas have been defined in the Edmonton formation, namely:—

Coal Area	Townships	Ranges	Meridian
Wetaskiwin	41 to 49	22 to 27	W. of 4th
Whitecourt	53 to 60	9 to 12	5th

The revised coal areas map now includes 45 coal areas, divided as follows:—

Kootenay—10 coal areas

1. Smoky River
2. Brule
3. Mountain Park
4. Nordegg
5. Clearwater
6. Panther
7. Cascade
8. Highwood
9. Oldman
10. Crowsnest

Belly River or **Saunders**—21 coal areas

1. Halcourt
2. Prairie Creek
3. Coalspur
4. Saunders
5. Morley
6. Pekisko.
7. Pincher
8. Magrath
9. Lethbridge
10. Milk River
11. Pakowki
12. Taber
13. Redcliff
14. Brooks
15. Steveville
16. Empress
17. Wainwright
18. Pakan
19. Rochester
20. Sexsmith
21. Valhalla

Edmonton—14 coal areas

1. Pembina
2. Edmonton
3. Tofield
4. Camrose
5. Castor
6. Ardley
7. Big Valley
8. Carbon
9. Sheerness
10. Drumheller
11. Gleichen
12. Champion
13. Wetaskiwin
14. Whitecourt

It is suggested to the reader that the new coal areas, as defined above, be added to his copy of the original map until such time as a revised coal areas map is published. When these new areas are added, it will be noticed that an extension of the Belly River rocks outcrops along the eastern side of the province, east of the Edmonton formation. The general geological structure is trough-like, with the axis of the depression trending north-northwest. Belly River coal mined within the areas east of the Edmonton coal areas will be less mature than some of the coal in the Edmonton formation to the west.

"The Coal Sales Act, 1925",* assented to April 10, 1925, legalizes these coal areas insofar as they are used in the sale of coal.

It may be necessary from time to time to add new areas as new coal fields are opened up. The boundaries of these areas will be defined only after a careful geological survey has been made of the district and chemical analyses made of the coal.

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*Statutes of Alberta, 1925, Cap. 21. A copy of this act may be obtained from the King's Printer, Edmonton, Alta.

THE BITUMINOUS SANDS OF NORTHERN ALBERTA

By K. A. Clark and S. M. Blair

Until the year 1924, work on the bituminous sands of Alberta was confined almost entirely to a study of how their bitumen content can be separated from the sand with which it is mixed, and of the application of the crude separated bitumen to the stabilization of rural earth roads. Very little attention had been given to the bituminous sand deposit itself. During the season of 1924, a field party was placed in the bituminous sand area to make a detailed study of the method of occurrence of the bituminous sands, to note any features of the deposit having a bearing on the study of the separation of the bitumen and its practical uses, and to get the information required for deciding how the bituminous sands can be mined or excavated, and at what probable cost.

The study of the separation of the bitumen from the bituminous sands and the application of the bitumen to earth road stabilization was continued. A new separation plant was designed, constructed, and set in operation. Plans were laid for experimental road construction as soon as sufficient bitumen for the project was forthcoming from the separation plant.

Field Examination of the Bituminous Sands

The field examination of the bituminous sands was planned and carried through by S. M. Blair. The party, including also G. J. Knighton, assistant, two helpers and a cook, left Edmonton on May 20, and returned on September 13. The party conducted its work over that part of the bituminous sand area which can be regarded as having any immediate commercial significance. Thirty-five representative exposures of bituminous sand were examined in detail. A shaft was sunk into the bituminous sand deposit to a depth of forty-five feet. Approximately two hundred and fifty samples of material were collected from the exposures examined, and from the shaft. These were sealed up in air-tight cans, and shipped to the laboratories at Edmonton for analysis. Some large samples were also collected, including half a ton of bituminous sand from the shaft. Bitumen seepages were examined and sampled, and many other features of the bituminous sand deposit were noted.

The Bituminous Sand Area Examined

The bituminous sand deposits have been frequently described.* Suffice it here to mention that an area of at least 1,000 square miles underlain by bituminous sands is indicated by the bituminous exposures along the Athabaska river from the neighborhood of McMurray down stream for sixty miles, and along the tributary streams entering the Athabaska. The area is no doubt much larger than this; but it is only that part of the bituminous deposit which is accessible that is of any immediate interest. The Alberta and Great Waterways Railway runs from Edmonton northward 300 miles to Waterways on the Clearwater river, six miles from McMurray. River navigation is carried on by shallow draft steam boats from Waterways along the Clearwater and Athabaska rivers through the extent of the bituminous sand area.

The area underlain by the bituminous sand formation is covered by a growth of poplar, spruce, willow, jackpine, and tamarac. The drainage of the country is not well developed, and much of the land back from the valleys consists of muskeg and swamp. The overburden covering the bituminous sand formation is the thickest in the southern part of the area, decreasing in thickness in the central part, and increasing again to some extent toward the extreme north, where the formation pinches out.

The field party examined the bituminous sand occurrences along the Athabaska river from McMurray down stream for sixty miles. Exposures along the tributaries of the Clearwater and Athabaska rivers were examined, as follows: Christina river, 8 miles; Hangingstone river, 4 miles; Horse river, 4 miles; Steepbank river, 8 miles; Muskeg river, 4 miles; McKay river, 10 miles; and Ells river, 10 miles.

Method of Examining Outcrops

The method adopted for conducting the field examination consisted in making cross-sections of the strata in the bituminous outcrops. Outcrops offering the maximum opportunity for observation of lateral as well as vertical variations in the nature of the beds were chosen for study. The first operation of working an exposure was the digging of a trench from top to bottom through the weathered surface into fresh material. The trench was a continuous one if conditions permitted. Otherwise, a trench was made in sections covering the entire thickness of exposed beds. Where rich beds of bituminous sand were crossed, it was not necessary to dig the trench to a depth of more than a few inches to reach fresh material; but in the case of lean, weathered beds, and where talus had accumulated, several feet of material had to be removed. When the entire thickness of fresh beds was brought to light, the beds were examined, divided into logical divisions, and a detailed description of them recorded. A profile of the exposure was prepared, and the position of the points of division of strata accurately located. In addition to the field examination and description of the beds, careful sampling of them was carried out to enable laboratory examination to be done. A channel sample through each division of strata was cut from the fresh material exposed by the trench. A large sample* was thus secured, which was then quartered down to one weighing approximately four pounds for packing and sealing in quart air-tight sample tins in which the samples were shipped to the laboratory in Edmonton.

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*Preliminary Report on the Bituminous Sands of Northern Alberta, S. C. Ells; (No. 281, 1914) Mines Branch, Canada.

Summary Reports, Mines Branch, Canada, from 1913 to date.

First and Second Annual Reports on The Mineral Resources of Alberta, J. A. Allan; Scientific & Industrial Research Council of Alberta (1920 and 1921).

An alternative method of examining the bituminous area would have been by means of drilling. Drilling operations, however, are confronted by serious difficulties as well as advantages. The procedure adopted by the field party seemed to be the better method for the immediate objective in view. By means of it, a fairly complete practical knowledge of the accessible portion of the bituminous formation was gained expeditiously and at small expense. Furthermore, it was understood that the Mines Branch, Ottawa, was planning to carry out drilling tests.

Laboratory Examination of Samples

The bituminous sand samples, on reaching the laboratory, were examined to determine the percentage of bitumen, water and mineral matter which they contained, the specific gravity and sulphur content of the bitumen, and the mechanical grading of the sand. The water plus bitumen content was found by extracting the bituminous sand with benzene, and drying and reweighing the extracted sand. The water content was determined separately by the distillation method of the Amercian Society for Testing Materials.† By carefully distilling off the bulk of the benzene from the extraction of the bituminous sand sample, and evaporating the remaining solvent on a waterbath, a sample of the bitumen was secured for specific gravity and sulphur determinations. Specific gravity determinations were made by means of picnometers. Sulphur determinations were made by the bomb method.‡ The extracted sand was submitted to physical analysis by means of a set of Tyler sieves.

Record of Field and Laboratory Data

The complete record of field data relating to two of the thirty-five bituminous sand occurrences examined are given below and in Figures 4 and 5. The corresponding laboratory data are given in Tables V. and VI.

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*The large samples weighed from fifty to one hundred pounds. This weight varied with the thickness of the strata sampled.

†A. S. T. M. Standard Test D-95-24.

‡The sulphur determinations were made by W. P. Campbell, Fuel Analyst.

Cross-Section No. 2, Description of Strata

Strata	Description	Thickness feet
Overburden	Heavy overburden covered with trees and rapidly increasing in thickness back from the exposure..	....
1A	Very lean beds of bituminous sand with bands of shale interbedded; obviously weathered	3.3
1B	Lean but massive bituminous sand; shale bands fewer and thinner than in 1A; prominent shale band 30″ thick near centre of 1B, with showing of white salt† crystals	10.0
2	Uniform, hard, massive, cliff-forming bituminous sand of medium richness	12.3
3A	Massive, fairly rich, cliff-forming bituminous sand	6.1
3B	Massive, hard, cliff-forming bituminous sand; leaner and more stratified than 3A	10.2
4	Massive bituminous sand, showing irregular cleavage; lean at top, getting richer toward the bottom; salt† crystallizes out along lines of minor stratification, with pronounced showing at the bottom of this division	7.7
5A,B,C,D	Massive, rich bituminous sand; cross bedding apparent; cleavage parallel to face; bitumen seeping out has coated the face of B in some places...........	48.0
Talus	....	6.5
	Total thickness...................	104.1

Cross-Section No. 32, Description of Strata:—This bituminous sand occurrence was studied more intensively than some others by means of surveying and trenching.

The overburden consists of sand and clay of a depth varying from 3 to 6 feet, and is covered with a growth of spruce.

There is a thickness of approximately sixty feet of bituminous sand strata. The bituminous sand is essentially uniform in nature and is massive, rich, soft, and homogeneous. Very few partings of lean material occur. There is no outstanding form of cleavage apparent, and no showing of salt crystallization on the surface of the exposures. The strata have been divided into four divisions rather arbitrarily for purposes of sampling. The only characteristic affecting the choice of division was a seeming difference in tendency toward cliff-formation at different elevations.

This occurrence is one of a series of shoulders that stand out along the Athabaska river for one and a half miles.

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†The salt crystals found on the surface of bituminous sand exposures are not necessarily crystals of common salt (sodium chloride). An analysis of one sample of these crystals is given on page 62.

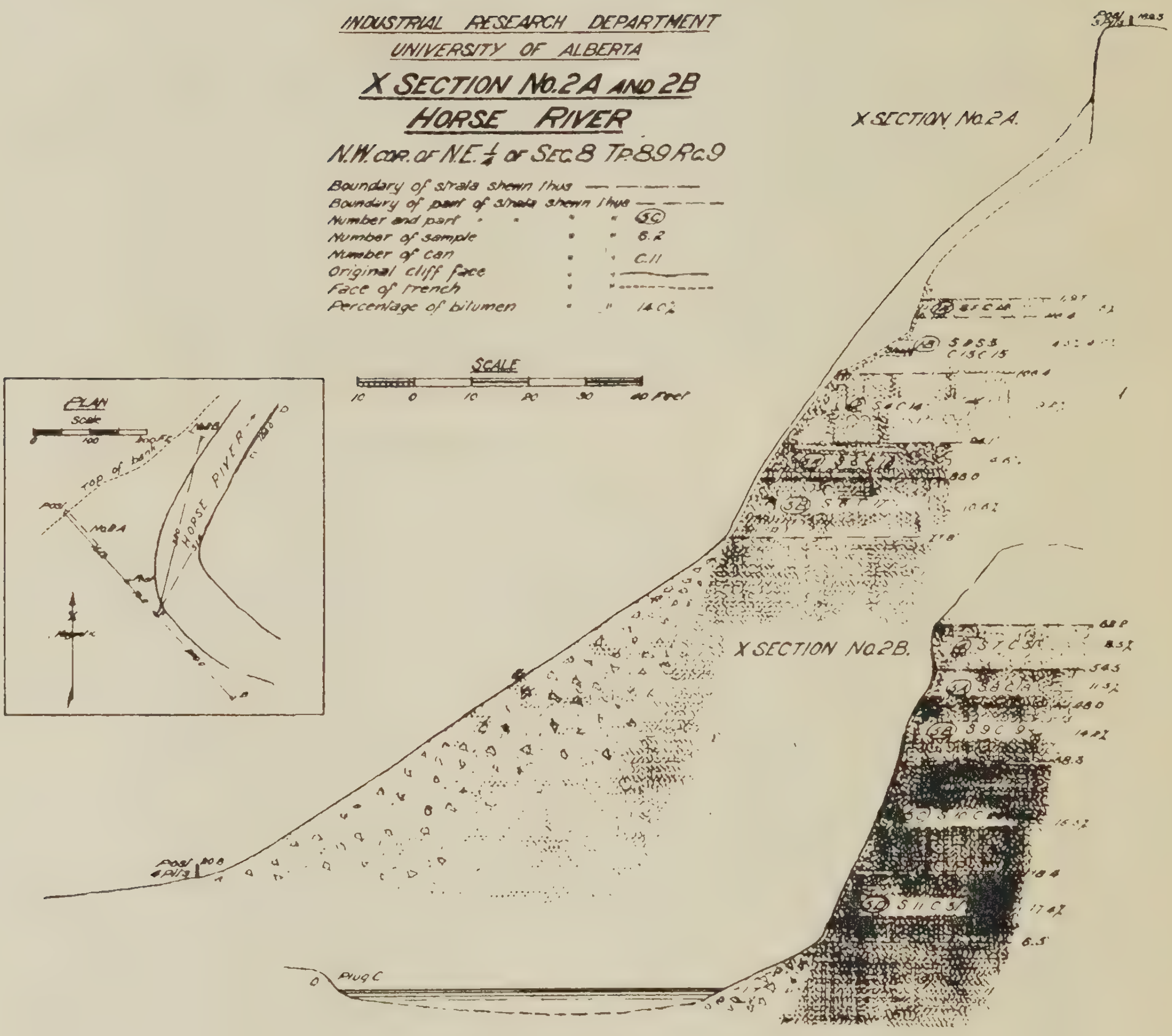

Figure 4.—Cross-Section No. 2

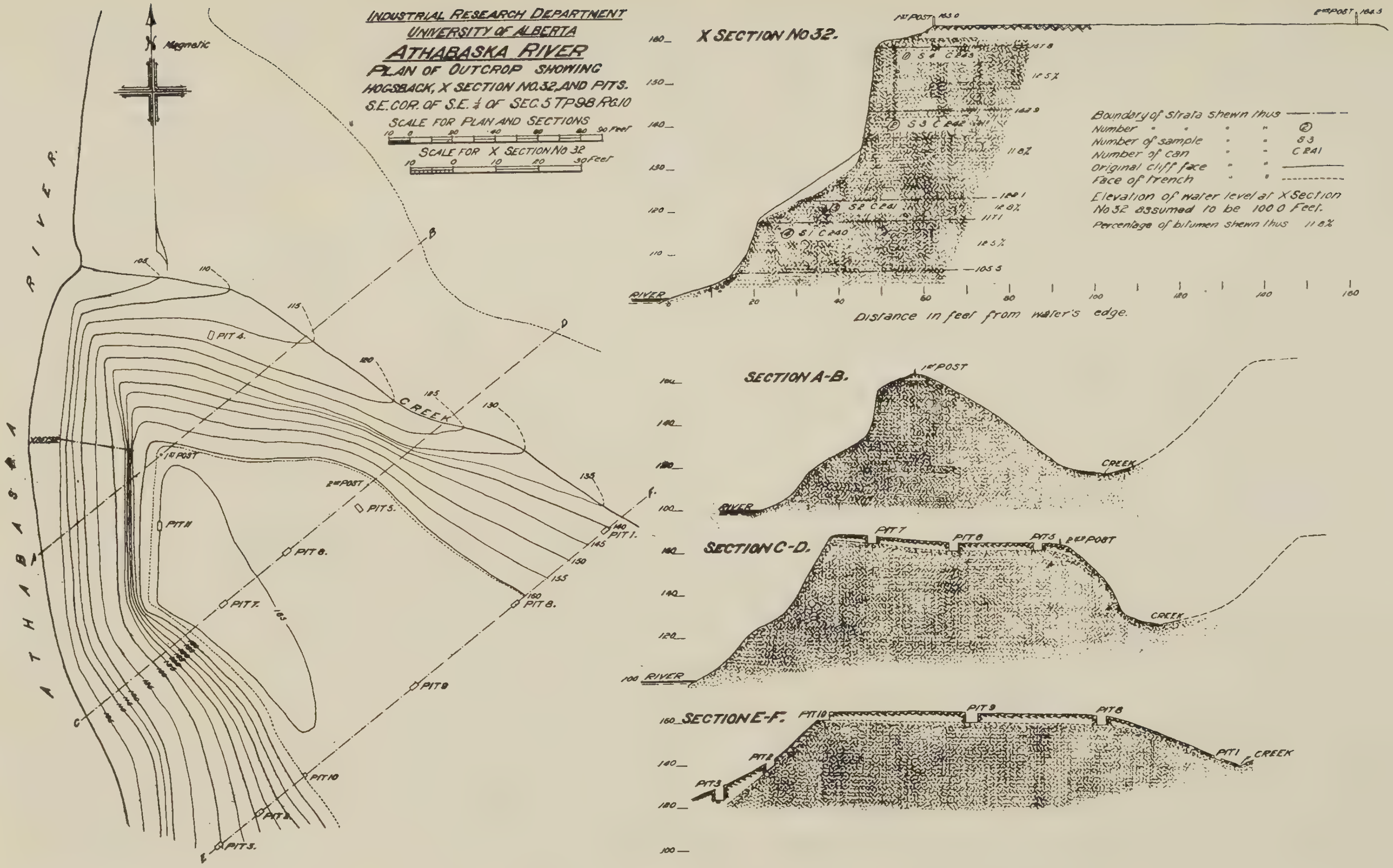
INDUSTRIAL RESEARCH DEPARTMENT
UNIVERSITY OF ALBERTA
ATHABASKA RIVER
PLAN OF OUTCROP SHOWING
HOGSBACK, X SECTION NO.32, AND PITS.
S.E. COR. OF S.E. ¼ OF SEC. 5 TP. 98 R.G. 10
SCALE FOR PLAN AND SECTIONS
SCALE FOR X SECTION No 32
Magnetic
ATHABASKA RIVER
CREEK
PIT 1.
PIT 2.
PIT 3.
PIT 4.
PIT 5.
PIT 6.
PIT 7.
PIT 8.
PIT 9
PIT 10
PIT 11
1st POST
2nd POST
X SECTION No 32.
1st POST 153.0
2nd POST 162.5
Boundary of Strata shewn thus
Number " " "
Number of sample
Number of can
Original cliff face
Face of trench
Elevation of water level at X Section No 32 assumed to be 100.0 Feet.
Percentage of bitumen shewn thus 11.8%
Distance in feet from water's edge.
RIVER
SECTION A-B.
SECTION C-D.
SECTION E-F.

Figure 5.—Cross-Section No. 32

TABLE V.—RESULTS OF ANALYSIS OF SAMPLES, CROSS-SECTION No. 2, HORSE RIVER

Strata No.	Part of Strata	Composition of Sample, %			Screen Analysis of Mineral Matter, %				Character of Bitumen	
		Bitumen	Mineral Matter	Water	Retained on Mesh			Passing Mesh	Sp. Gr. 25°/25° Cent.	Sulphur Content, %
					48	100	200	200		
1	A	1.6	92.6	5.8	....	9	43	48	....	....
1	B	4.5	92.2	3.3	....	3	67	30	1.025	4.7
1	Shaly part of B	5.2	90.2	4.6	....	7	57	36	1.025	4.7
2	....	9.2	86.7	4.1	....	3	74	23	1.030	....
3	A	14.6	84.1	1.3	....	6	76	18	1.025	4.8
3	B	10.6	89.1	0.3	....	31	56	13	1.030	....
4	....	8.5	91.2	0.3	....	18	69	13	1.025	....
5	A	11.5	88.0	0.5	....	45	48	7	1.030	5.0
5	B	14.2	85.2	0.6	1	33	53	13	1.025	....
5	C	15.5	83.7	0.8	1	57	35	7	1.025	....
5	D	17.4	82.2	0.4	....	27	65	8	1.025	5.0

TABLE VI.—RESULTS OF ANALYSIS OF SAMPLES, CROSS-SECTION No 32, ATHABASKA RIVER

Strata No.	Part of Strata	Composition of Sample, %			Screen Analysis of Mineral Matter, %				Character of Bitumen	
		Bitumen	Mineral Matter	Water	Retained on Mesh			Passing Mesh	Sp. Gr. 25°/25° Cent.	Sulphur Content, %
					48	100	200	200		
1	....	12.5	84.3	3.2	....	5	84	11	1.025	....
2	....	11.8	82.8	5.4	....	9	83	8	1.020	....
3	....	12.8	80.8	6.4	....	8	80	12	1.025	....
4	....	12.5	84.4	3.1	....	3	87	10	1.020	....
Sample from pits		5.8	87.9	6.3	....	3	83	14	....	....

Shaft into the Bituminous Sand

Examination of outcrops was open to a criticism which might have proved a serious one. Bituminous sands occurring within easy reach of the surface of an exposure might not be strictly comparable to the material comprising the body of the deposit back from the surface; and even though care were taken to strip off the surface material which had been enriched, leached or otherwise affected by weathering, and apparently fresh material brought to light, this material might still be somewhat altered, due to its proximity to the surface.

Some means of comparing the apparently fresh material from outcropping bituminous sand beds with material from the same beds well back from the exposure was desirable. The comparison was made by sinking a shaft into fresh beds of bituminous sand, and noting how the nature of the bitumen in them agreed with that in the same beds where they came to the surface on an outcrop. A site for the shaft was chosen where the bituminous beds could be reached by digging through about fifteen feet of overburden on a river flat. Bituminous sand beds were exposed on the face of a cliff at the bend of the river about 1,500 feet away. The lower beds at the cliff corresponded to the upper beds reached by the shaft.

The sinking of the shaft gave information about another matter. The draining of petroleum by means of shafts and galleries from the oil field at Pechelbronn, Alsace, which had ceased to yield oil by means of drilling wells, has attracted much attention of late. It has been suggested from various quarters that this mining method would be found to be admirably suited to the bituminous sand deposits of Alberta.* The suggestion has not appealed to those familiar with our deposits; but still it was desirable to obtain some definite information as to whether the bituminous sands would drain or not. The shaft gave opportunity of making observations along this line.

The site for the shaft was in the valley of Horse River, about one mile and a half upstream from the mouth, and about one hundred feet back from the river's edge.† The shaft was four feet square, and was sunk to a depth of forty-five feet. This depth placed the bottom of the shaft twenty feet below the water level in the river. The excavating was done by picks and shovels, with the assistance of slow explosives. The shaft through the overburden was cribbed tightly with lumber; the part through the bituminous sand was cribbed with flattened poles set vertically. A section of one side was left unobstructed to make possible subsequent observations. The material penetrated by the shaft was examined and sampled.

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*"Working Petroleum by Means of Shafts and Galleries," contribution to discussion by Mr. Cunningham Craig, J. Inst. Pet. Tech., July, 1921, p. 191.

†The shaft was situated on the bituminous sand reserve of the Parks Branch, Department of the Interior, Ottawa. Thanks are due to the Parks Commissioner for permission to sink the shaft.

The nature of the shaft and of the bituminous sand beds through which it passed are described below and illustrated in Figure 6. The laboratory data are given as Table VII.

Shaft on Horse River, Description of Strata.—The overburden consists of fifteen feet of bands of sand, sandy clay, bituminous sand, rubble, and boulders. The boulders occur at the bottom of the overburden, and immediately overlying the bituminous sand strata.

The bituminous sand strata are of fairly constant nature for the entire thirty feet penetrated. They consist of rich, uniform material. One thin, compact parting of bituminous sand is the only indication of banding. A number of marcasite nodules varying in size from one to six inches in diameter occur imbedded in the bituminous sand. A certain amount of cross-bedding occurs.

An auger hole drilled four feet into the bottom of the shaft reached a layer of clay. This clay probably represents the bottom of the bituminous sand formation. Water smelling strongly of sulphuretted hydrogen entered the shaft from this clay. The only other water entering the shaft, except for the drops which formed on the bituminous sand walls, was that which entered from immediately underneath the overburden.

TABLE VII.—RESULTS OF ANALYSES OF SAMPLES, SHAFT ON HORSE RIVER

Depth in Shaft, feet	Composition of Sample, %			Screen Analysis of Mineral Matter, %				Character of Bitumen	
	Bitumen	Mineral Matter	Water	Retained on Mesh			Passing Mesh	Sp. Gr. 25°/25° Cent.	Sulphur Content, %
				48	100	200	200		
15—17	13.1	81.6	5.3	....	47	48	5	1.020	5.0
17—19	14.4	81.1	4.5	....	50	45	5	1.020	5.4
19—21	16.0	80.9	3.1	....	41	52	7	1.020	4.9
21—23	14.9	81.7	3.4	....	47	46	7	1.020	5.2
23—25	15.9	81.9	2.2	....	57	37	6	1.020	5.0
25—27	15.8	80.6	3.6	....	51	42	7	1.020	....
27—29	16.0	81.9	2.1	....	57	38	5	1.020	....
29—31	16.7	80.2	3.1	....	64	33	3	1.020	....
31—33	15.6	81.8	2.6	....	48	47	5	1.020	....
33—35	17.2	80.5	2.3	....	62	32	6	1.020	....
35—37	12.2	80.4	7.4	3	59	25	13	1.020	....
37—39	16.0	79.7	4.3	....	69	26	5	1.020	....
39—41	15.6	79.5	4.9	....	80	15	5	1.025	....
42.5	10.8	72.7	16.6	14	65	16	5	1.025	5.2
45	....	clay							

Validity of Information Secured by Examination of Outcrops

Cross-section No. 2 and the data pertaining to it were chosen to illustrate the sort of information that has been secured, because it represents an outcrop located near the shaft. Comparison of the results of analyses of samples from it and from the shaft permit of the forming of a judgment as to how truly information obtained

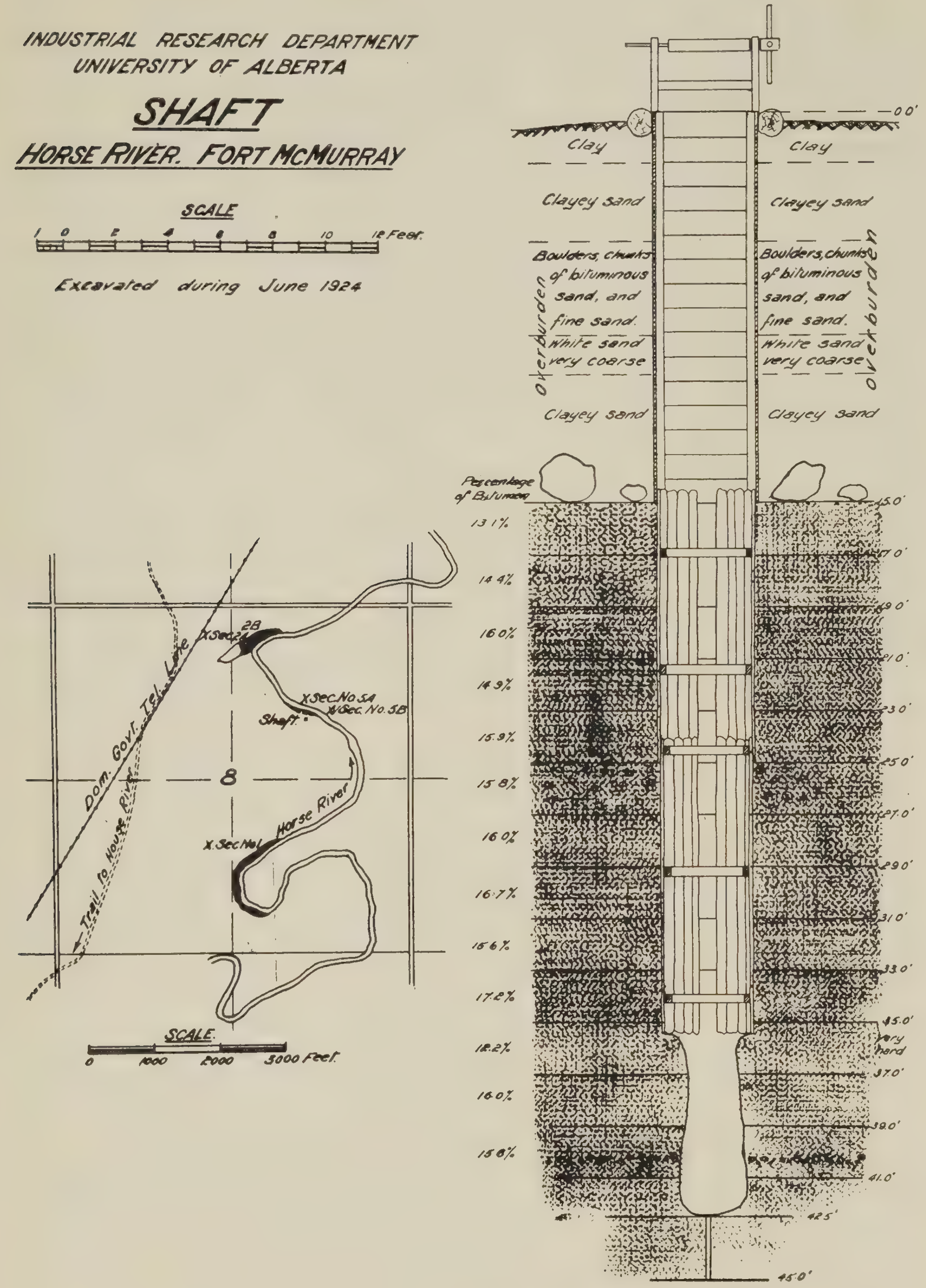

Figure 6.—Section of Shaft in Bituminous Sands

from the examination of outcrops can be considered as applying to the material which lies back of the exposures and yet might be reached by examination on a commercial scale. The outcrop corresponding to Cross-section No. 2 is located about 1,500 feet away from the shaft. The bottom fourteen feet of the outcrop correspond in elevation to the top fourteen feet of the bituminous sand penetrated by the shaft.

The effect of weathering factors on the bituminous sand would be to cause changes in the bitumen constituent. Little change could take place in the sand. But it is interesting to note that the corresponding beds in the outcrop and in the shaft are similar as regards the mineral matter. The sand at both locations is essentially a very fine sand, although somewhat coarser at the shaft. The proportion of silt (material passing the 200-mesh sieve) is low, and substantially of the same percentage at outcrop and shaft. If the material near the surface of the outcrop were affected to any great extent by weathering, decided differences in the percentage of bitumen present, and especially in the specific gravity of the bitumen, should be obvious when material from the surface and from a position back from the surface are compared. No such differences occur. Both the percentage of bitumen and its gravity correspond well for the bituminous sand at the outcrop and in the shaft. The gravity is slightly higher, and the water content is lower at the surface of the outcrop. These features could be interpreted as indicating a certain degree of weathering effect; but the very close correspondence between outcrop and shaft samples certainly demonstrates that fresh beds reached by digging through the covering of weathered material on the face of an exposure approximate closely to the condition of the bituminous sand beds as far back from the face as commercial workings would extend.

Information Gained from the Shaft

The sinking of the shaft, in conjunction with the study of the neighbouring outcrops, brought out the fact that the effect of weathering of bituminous sand beds of good quality and of commercial significance is confined almost entirely to the outside few inches of an exposure.

The operation of digging the shaft indicated some features about the fresh bituminous sand bearing on the general problem of mining. Excavating the shaft by hand proved slow work, but certain ways of carrying on made faster headway than others. The best way seemed to be to loosen up a hole in the centre of the bottom of the shaft by explosives, and then slice off the sides of the hole with a shovel. This ready slicing off of thin layers is suggestive of the types of excavating machinery that might be used in working the bituminous sands.

No tendency whatever was noted for the bitumen to drain out of the bituminous sand beds into the shaft during the three months it was under observation. The bitumen seems to be entirely too viscous to move through the very fine sand in which it is contained. Evidence from the shaft is against the applicability of the gravity drainage methods of Alsace for petroleum mining to the Alberta bituminous sands, at least to that part of the deposit accessible from the valleys. To discuss the applicability of the method to the main deposit away back from the valleys is outside the scope of this report.

Information Gained from Examination of Bituminous Sand Exposures

General Nature of the Bituminous Sands.—A presentation of the detailed information secured from the examination of the bituminous sand exposures can not be made in this summary report. But a number of general statements, based on the detailed data collected, can be given.

The general appearance of an exposure, and the superficial indications of the sort of bituminous sand it contains, can be very deceiving. It is unsafe to form any conclusion about the material that lies behind a bituminous sand exposure until the surface material has been stripped away and the fresh beds brought to view. As a general rule, the individual bands of bituminous sand contrast sharply with each other. Bands containing different percentages of the bitumen, water, and mineral matter constituents generally behave differently under the influence of weather, and the change from a bed of one material to another is thus made apparent. But it often happens that bituminous sands of widely varying bitumen content weather to the same general appearance. It is impossible to be sure of the nature of the material outcropping in an exposure without first removing the weathered surface and securing a fresh section through the beds from top to bottom.

Cross sections of ordinary bituminous sand outcrops present varying successions of minor strata and bands. These consist of varying grades of bituminous sand and of silt or clay. Many of the bands, particularly in the upper part of the formation, are lenticular. There is a great variation in the thickness of the lenses and also in the rapidity with which they pinch out laterally. Division into thin beds, and the occurrence of lean bituminous sand, are characteristic of the upper portion of the formation; thicker beds and richer bituminous sand characterize the lower portion of the formation. This generalization, however, has exceptions, as exposures were found where one or more strata of rich bituminous sand occurred toward the top of the formatin.

The bitumen content of the various bands appearing in an outcrop may vary from one to twenty per cent., but seldom exceeds sixteen per cent. When bituminous sand is called "rich" or "of commercial significance," it is meant that its bitumen content is nine per cent. or greater. Rich bituminous sand is cliff-forming, and has a cleavage which may be either irregular or parallel to the face of the exposure. It may be homogeneous and massive, or have distinct minor divisions and cross-bedding.

Lean bituminous sand, as the term is used in this report, includes bituminous sand containing less than nine per cent. of bitumen, and beds of rich bituminous sand which individually are too thin for commercial significance and which when combined with the associated bands give an average material containing less than nine per cent. of bitumen. The lean bituminous sand is not compact, has little cleavage, does not weather to a hard surface, and is not cliff-forming. The lean material may be homogeneous for a considerable depth, or it may be thinly bedded with partings of rich bituminous sand, clay, or even lignite.

The outcrops on the banks of the rivers, and being eroded by the rivers, are of fresh bituminous sand. Other outcrops have weathered surfaces.

In general, the bituminous sand formation consists of two main economic divisions—a lower and an upper division. The lower division immediately overlies the Devonian limestone. It is more constant in nature over the bituminous sand area than the upper division. At some points it has a thickness of one hundred feet. It has a much higher average bitumen content than the upper division, and generally has a decided cliff-forming tendency. In comparison with the upper division it has remarkably few bands or lenses of clay or lean bituminous sand.

The upper division is irregular in nature. It consists of all the bands of lean and rich bituminous material overlying the lower division. The subdivisions vary in number, thickness, and nature in different areas of the bituminous sand formation. There are, however, some divisions of commercial significance. These are shown by certain outcrops on the lower Christina river, on Deep creek, and on Hangingstone and Horse rivers. Subdivisions of high grade bituminous sand thirty feet in thickness may be found in this area in the upper division. There is a large amount of material in the upper division in many areas, however, which is composed of bands of lean bituminous sand with much thinner partings of rich bituminous sand as well as partings of clay or silt. This material is eroded much more easily than rich material. The upper division also contains all the bituminous sandstone, in contradistinction to the bituminous sand. This sandstone is hard and compact, partially saturated with bitumen, and occurs near the top of the formation. There are seldom more than three thin bands, varying from four inches to a few feet in thickness. Bands from six to eight inches thick are the most common. There are occasionally very thin partings of brown lignite coal in the upper division.

There appears to be little change in the nature of the bitumen contained in the bituminous sand throughout the area. It is always a heavy, dark brown, viscous oil, and with few exceptions has a specific gravity between the values of 1.010 and 1.035 (25°C./25°C.). A few values as high as 1.050 were found, but these are in all probability to be accounted for by weathering. The bituminous area accessible from Ells river seems to be exceptional as regards the gravity of the bitumen. Specific gravity values from the bitumen of samples collected from this locality ranged from 1.005 to 1.015.

The sulphur content of the bitumen is consistently high, and ranges from 4.5 to 5%.

There is a considerable amount of variation in the mineral matter with which the bitumen is associated. The most marked contrast is that between the sand beds and the clay or silt beds. But the sand beds themselves vary both in the amount of silt or clay they contain and in the sizing of the sand particles. Rich bituminous sand, as a general rule, has a mineral constituent of which less than 15% will pass the 200-mesh Tyler sieve. Some notable exceptions to this rule are met; and the converse of the rule is in nowise true. Samples of rich material sometimes contain much more than 15% of very fine mineral matter; and high bitumen content does not necessarily go with a low percentage of material passing the 200-mesh sieve. The sand consists mostly of fine particles. Most of the mechanical analyses show less than 10% of the particles retained on the 48-mesh Tyler sieve. Higher percentages of particles retained on this sieve are not uncommon, however, and values as high as 75% have been noted.

The sand consists essentially of quartz particles of varying size. Flakes of mica are always evident, and particles of dark-colored minerals (chiefly marcasite) are almost always present. The proportion of particles other than quartz is small, but is a variable from one bed to another as well as from one location to another. Silt and clay in varying proportions are associated with the sand, and fragments of lignite are often present.

Nodules of marcasite varying in size up to eight inches in diameter are found embedded in the bituminous sand. Such nodules were encountered while sinking the shaft into the rich bituminous sand beds on Horse river. They were found irregularly embedded through one particular band of about eighteen inches. Nodules are found lying about the base of bituminous sand exposures throughout the area. Occasional pebbles are also scattered through the bituminous sand. Partings of very fine quartz gravel are frequently met in some areas.

Types of Bituminous Sand Occurrences.—Three types of localities are indicated by the bituminous sand outcrops:—

I. Localities with heavy overburden, i.e., 50 feet or more.

II. Localities with light overburden underlain by the whole thickness of the bituminous sand formation.

III. Localities with light overburden underlain by only the lower division of the bituminous sand formation.

I. Localities with Heavy Overburden.—That part of the bituminous sand area lying back of the actual valleys of the Clearwater, Christina, Hangingstone, Horse, and Steepbank rivers, part of the McKay River valley, and most of the Athabaska River valley exemplify this type of bituminous sand occurrence, which includes a very large proportion of the total bituminous sand formation.

II. Localities with Light Overburden Underlain by the Whole Thickness of the Bituminous Sand Formation.—There are areas of considerable extent in the neighborhood of parts of McKay river and of Ells river, which have a light overburden underlain by the whole thickness of the bituminous sand formation. It is only natural to find that the quality of the top strata of bituminous sand in these areas varies from place to place. In many instances a considerable thickness of these top strata would have to be removed with the overburden in any commercial operation. There are small, isolated sections in the valleys of the rivers in the southern part of the area where erosion has removed the bulk of the overburden from very limited areas.

III. LOCALITIFS WITH LIGHT OVERBURDEN UNDERLAIN BY ONLY THE LOWER DIVISION OF THE BITUMINOUS SAND FORMATION.—There are two classes of areas included under this type. First, there are the river flats and oxbows which are found notably in the valleys of the Christina, Hangingstone, Horse, Steepbank, and McKay rivers. These are underlain almost invariably by rich bituminous sand. There are oxbows with light overburden underlain by at least forty feet of rich beds, twenty feet of which may be above the water level of the river. Secondly, there are other areas of very appreciable extent from the development standpoint, occurring along the Athabaska River valley in the form of benches, where rich bituminous sand is covered by a light overburden. These benches are found mostly in the northern part of the bituminous sand area, but commence about eight miles below McMurray. The principal occurrences are between McKay settlement and the middle of township 98. They are well exemplified by areas near the mouth of the Calumet river.

The overburden covering the bituminous sand formation is thickest in the southern part of the bituminous area, decreases in the central part, and increases again to a certain extent in the extreme northern part where the bituminous sand formation pinches out.

Miscellaneous Notes.—The actual contact between the bituminous sand formation and the Devonian limestone is seldom exposed. Where both the bituminous sand and limestone appear above the water level, the contact is usually obscured by slides or covered by talus. But although the nature of the contact is not proved, rich bituminous sand in many areas directly overlies the limestone. In other sections, the two are divided by thin lenses of lignite coal, carbonaceous shale, and clay.

Bitumen seepages form an interesting feature of the bituminous sand area. These occur particularly in the northern part of the area. Many of these were examined. In many cases it appears evident that the seepage is caused by water moving through the bituminous sand and separating out a certain amount of the bitumen. Considerable accumulations of bitumen would seem to have been made in some places in this way, although the water flow has now ceased. These accumulations are now covered or sealed over by hard, brittle material. If this surface is broken, the softer bitumen of the interior will slowly flow by gravity. Water moving through breaks in the bituminous sands caused by recent slides has a good chance to bring out a certain amount of bitumen. The heat of the sun on a surface of rich bituminous sand will cause a small quantity of bitumen to collect on the face of the outcrop, giving rise to surface enrichment.

Salt crystals are often found on the face of bituminous sand exposures in the southern part of the area. These seem to be caused by the evaporation at the surface of water moving through the sand. A quantity of these crystals were collected and analysed.* The analysis showed:—

Ferrous Sulphate	13%
Calcium Sulphate	36%
Magnesium Sulphate	32%
Sodium Sulphate	19%

An interesting observation is that no seepages occur in the part of the bituminous area where showings of these salt crystals are found.

Three water samples were collected from bitumen seepage holes. Another sample was taken of the water which entered the shaft on Horse river. The shaft is in the southern part of the bituminous area where the salt crystals are found on the outcrops. None of these four water samples was large enough to permit of detailed analysis.

Sample No. 1.—From a seepage hole on the Athabaska river about 2 miles below McKay Settlement on each side. Hole was cleaned out several days before sample was obtained.

Sample No. 2.—From a seepage hole on the Athabaska river opposite the mouth of Tar river. Water bringing bitumen with it appears in the form of springs at the base of a hill. Water sample was obtained from a hole dug in the springy ground.

Sample No. 3.—From same location as No. 2. This sample was obtained from the top of the hill in a pit dug in the overburden. It represents surface seepage water.

Sample No. 4.—From the shaft on Horse river some months after the shaft was sunk.

Sample No.	1	2	3	4
	Parts per Million			
Total Solids	270	340	350	2,270
Alkalinity†	90	272	290	1,300
Sulphates (SO_3)	34	nil	nil	21.3
Sulphuretted Hydrogen	nil	0.25	0.25	36.0

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*Analysis made by J. A. Kelso, Provincial Analyst, University of Alberta.

†The alkalinity in No. 4 is due to carbonates of sodium, calcium, and magnesium; in Nos. 1, 2, and 3 to carbonates of calcium and magnesium.

A water sample collected from the shaft at the time of sinking it, and large enough to permit of detailed analysis, showed the following results on examination:—†

	Parts per Million	Grains per Gallon
Calcium Carbonate	84	5.9
Magnesium Carbonate	48	3.4
Sodium Carbonate	1,240	86.8
Sodium Chloride	707	49.5
Sodium Sulphate	26	1.8
Vegetable Matter	101	7.1
Sulphuretted Hydrogen	42	3.0

A number of outcrops of coal were encountered while examining the outcrops of bituminous sand. Those of chief significance were on the upper Athabaska, Christina, Steepbank, and McKay rivers. Occurrences in the latter three areas were examined, sampled, and analysed.

The occurrences of coal are in the form of bands, usually lenticular in form, underlying the bituminous sand formation. The coal is usually overlain by shale and minor bands of coal. In some cases, however, it is overlain directly by the bituminous sand. The bands in some cases are underlain by a small amount of shale and clay which, in turn, overlies the limestone; and in other cases the coal rests directly on the limestone.

The bands of coal sampled were in each case at least two feet in thickness, and the outcrops were traced for at least 100 feet.

There are numerous outcrops of coal along the Christina river. The bands vary in thickness from a few inches to about four feet. The following analysis* is of a channel sample from an outcrop showing in cross-section No. 7. This material is typical of the coal in the Christina River area. This particular occurrence is overlaid by bituminous sand and underlain by shale.

Location: Tp. 88, Rg. 6, W. 4th Mer. Sampler: S. M. Blair.
Method of Air-Drying: Standard. Loss on Air-Drying: 13.9%.

Proximate Analysis:	**As Received**	**Air-Dried**	**Dried**
Moisture ....%	28.0	16.4	......
Ash ....%	16.1	18.6	22.3
Volatile Matter ....%	25.1	29.2	34.9
Fixed Carbon ....%	30.8	34.8	42.8
Calorific Value, gross: B.T.U. per lb.	7,070	8,210	9,820
Fuel Ratio (Fixed Carbon/Volatile Matter)........		1.20	

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†Analyses of water samples made by J. A. Kelso, Provincial Analyst, University of Alberta.

*The coal analyses were made by W. P. Campbell, Fuel Analyst. The "Standard" method of air-drying consists of allowing the coal sample to dry in air maintained at 60% humidity (cf. 4th Annual Report, S. & I. R. C. A., p. 39.)

There are numerous outcrops of coal along the McKay river. The following analyses are of channel samples taken from two bands of coal each two feet in thickness. The bands are separated by one foot of clay. They are overlain by bands of clay containing minor bands of coal and underlain by four feet of clay which overlies the limestone.

Location: Tp. 96, Rg. 11, W. 4th Mer.
Sampled 11 Aug., 1924, by G. J. Knighton.

Upper Band of Coal

Method of Air-Drying: Standard. Loss on Air-Drying: 6.1%.

Proximate Analysis:	**As Received**	**Air-Dried**	**Dried**
Moisture ....%	14.2	8.6	......
Ash ....%	33.6	35.8	39.2
Volatile Matter ....%	24.5	26.1	28.6
Fixed Carbon ....%	27.7	29.5	32.2
Calorific Value, gross: B.T.U. per lb.	6,620	7,050	7,710
Fuel Ratio (Fixed Carbon/Volatile Matter)........		1.15	

Lower Band of Coal

Method of Air-Drying: Standard. Loss on Air-Drying: 6.8%.

Proximate Analysis:	**As Received**	**Air-Dried**	**Dried**
Moisture ....%	16.6	10.5	......
Ash ....%	14.9	16.0	17.9
Volatile Matter ....%	31.4	33.7	37.6
Fixed Carbon ....%	37.1	39.8	44.5
Calorific Value, gross: B.T.U. per lb.	8,600	9,230	10,300
Fuel Ratio (F.C./V.M.)		1.20	

There are fewer occurrences of coal in the Steepbank area than along the Christina or McKay rivers. The following analysis is of a channel sample of a band of coal three feet thick. The outcropping shows in Cross-section No. 14. This band is overlain by bituminous sand, and is underlain by the limestone.

Location: Tp. 92, Rg. 9, W. 4th Mer.
Sampled 2 Aug., 1924, by G. J. Knighton.
Method of Air-Drying: Standard. Loss on Air-Drying: 1.4%.

Proximate Analysis:	**As Received**	**Air-Dried**	**Dried**
Moisture ....%	12.4	11.2	......
Ash ....%	25.3	25.7	28.9
Volatile Matter ....%	25.3	25.7	28.9
Fixed Carbon ....%	37.0	37.4	42.2
Calorific Value, gross: B.T.U. per lb.	7,770	7,880	8,870
Fuel Ratio (F.C./V.M.)		1.45	

The Mining or Excavating of the Bituminous Sands

Two of the principal firms manufacturing steam shovel machinery in America were consulted on the questions of whether steam shovel equipment would be suitable for excavating the bituminous sands, and if so, the probable cost of operation. Their engineers were given the specific information about the bituminous sand formation for which they asked. Very definite final replies were received from both firms.

After a careful examination of a fairly large sample of the bituminous sand tightly rammed into a stout box, of general information regarding the formation, and of detailed information regarding the specific occurrence represented by Section No. 32 (c.f. pages 49 and 52), both companies stated without reservation that their standard steam shovels would dig the bituminous sand without difficulty, and that conditions pertaining to the third type of bituminous occurrences described in the previous section were suitable for steam shovel operations. One company estimated that bituminous sand could be excavated from the deposit at Section No. 32 and loaded into cars for 10c per ton. The other company gave the total cost of operating at this site one of their steam shovels capable of digging 1,500 tons per 10-hour day, from which it could be deduced that the cost per ton of bituminous sand mined and loaded would fall below 10c, provided upwards of 1,000 tons or more were mined per day.

BITUMINOUS SAND SEPARATION PLANT

The construction and operation of a small bituminous sand separation plant, and the use of the bitumen separated by it in a practical earth road stabilization experiment, were described in the Fourth Annual Report of the Scientific and Industrial Research Council of Alberta. The encouraging results of this work led to the undertaking of a more extensive programme of bituminous sand separation and experimental road construction. It was decided that a half-mile of experimental road should be constructed. It was estimated that the bitumen from approximately five hundred tons of bituminous sand would have to be separated for this work. This programme was begun in 1924.

A new experimental separation plant with an estimated capacity of 1 ton of bituminous sand per hour was constructed. A site for it was chosen alongside the railway tracks at the E.D. & B.C. Railway yards, Edmonton. W. G. Jewitt carried out the details of designing the plant, prepared drawings, made out specifications for the construction of its parts, engineered its erection, and took charge of its operation. The first trial run was made on August 12th. Runs were made intermittently, with interruptions for adjustments and improvements of the plant, until October 9th, when operations were discontinued on account of climatic conditions and frozen water pipes. Approximately one hundred tons of material were passed through the plant. Operations will be resumed as early in 1925 as weather will permit. A complete report of the separation plant and its operation will be given in the Sixth Annual Report.

ACKNOWLEDGMENTS

The Industrial Research Department wishes to express appreciation to those who have given assistance in carrying through the work of the year on bituminous sands. Those in charge of the erection of the plant of the Alberta Salt Co., Ltd., at the mouth of Horse river, near McMurray, showed a very friendly and helpful

spirit toward our field party, and helped in many ways. The lumber for cribbing the overburden section of the shaft was obtained from them. This was a great convenience. The same friendly and helpful spirit was shown by those at the McMurray Asphaltum & Oil Company's plant at Waterways. Dealings with merchants and transportation companies of the district were all characterized by a real spirit of co-operation.

Special acknowledgment is due the officials of the Department of Railways for help in carrying out the bituminous sand separation work at Edmonton. Permission to erect the plant at the E.D. & B.C. Ry. yards was obtained through this department; and the General Manager of the Provincial Railways, Mr. John Callaghan, gave valued help on many occasions in making arrangements for the erection and operation of the plant.

FOREST PRODUCTS OF ALBERTA: MINE TIMBER

By R. S. L. Wilson

Professor of Civil Engineering,
University of Alberta

The series of tests of lodgepole pine mine booms and props mentioned and described in the 1923 Annual Report has been continued during 1924. (See 1923 Annual Report, pages 74 to 75.) Inspections of the timber at the mine were made in April and July. The following conditions were noted:—

At "intake" there was no moisture nor fungus, and all test pieces were apparently as good as new.

At "No. 1 Return North" there was fungus up to ¼″ long on all pieces; no dripping or standing water; psychrometer readings indicated saturation. In July there seemed to be possibly less fungus.

At "No. 2 Return North" the conditions were as at "No. 1 Return North," except that there was some mud, but no drip. Air velocity was 250 feet per minute.

At "Dead Air" all the timber showed fungus; muddy floor; wet roof, but no drip; relative humidity, 93.

In September, 1924, ten "sets" peeled, and ten "sets" unpeeled were removed from "Dead Air" and tested for bending and compression strengths. The results obtained to date do not cover a sufficiently long period to enable an intelligent interpretation of the tests completed. It therefore seems advisable to withhold publication at present.

Booms are tested by bending under equal loads at third points on a span of 90 inches. Loads and central deflections are observed at frequent intervals to obtain the load-deflection curve. Props are tested by end compression on 52-inch lengths. Loads and axial strains on 50-inch gauge lengths are observed at frequent intervals to obtain the load-strain curve. For booms and props, all necessary dimensions are observed, and determinations of age and moisture content are made.

Acknowledgment of continued courtesies from Messrs. J. C. and A. C. Dunn and John Russell of the Great West Coal Company, Ltd., is gratefully made.

LIST OF PUBLICATIONS

OF

THE SCIENTIFIC AND INDUSTRIAL RESEARCH COUNCIL OF ALBERTA

ANNUAL REPORTS OF COUNCIL

Report No. 3 (for the calendar year 1920); pp. 36. **Price 5 cents.**

Report No. 5 (for the calendar year 1921); pp. 86. **Price 35 cents.**

Report No. 8 (for the calendar year 1922); pp. 64. **Price 35 cents.**

Report No. 10 (for the calendar year 1923) with 4-colour map of Alberta coal areas; pp. 76. **Price 50 cents. Map No. 6 only, 15 cents.**

Report No. 12 (1924); pp. 68.—Reviews the work done during 1924 under the auspices of the Research Council. This includes—the analysis, screening, storage, and briquetting of Alberta coals, their use in domestic heaters and for smithy purposes, de-ashing of coal, geological investigations by survey of the foothills belt and the plains along the Red Deer valley, soil distribution in south-eastern Alberta, aluminium sulphate, placer gold near Smith, changes in the map of Alberta coal areas, a field examination of the bituminous sands of northern Alberta, separation of the bitumen, the study of Alberta trees for use as mine timbers. **Price 35 cents.**

REPORTS—ALBERTA GEOLOGICAL SURVEY

By J. A. Allan, Professor of Geology, University of Alberta.

No. 1 (1919); pp. 104.—A summary of information collected with regard to the mineral resources of Alberta. **Price 10 cents.**

No. 2 (1920); pp. 138+14. Supplements the information contained in Report No. 1. **Price 25 cents.**

No. 4 (1921); GEOLOGY OF THE DRUMHELLER COAL FIELD, ALBERTA; pp. 72, and 6-color map (Serial No. 1). **Price $1.00.**

No. 6 (1922, Part I), GEOLOGY OF THE SAUNDERS CREEK AND NORDEGG COAL BASINS, ALBERTA, by J. A. Allan and R. L. Rutherford; pp. 76, and 2-color map (Serial No. 2). **(Out of print.)**

No. 7 (1922, Part II), AN OCCURRENCE OF IRON ON THE NORTH SHORE OF LAKE ATHABASCA, by J. A. Allan and A. E. Cameron; pp. 40, two maps (Serial Nos. 3 and 4). **Price 25 cents.**

No. 9 (1923); GEOLOGY ALONG BLACKSTONE, BRAZEAU AND PEMBINA RIVERS IN THE FOOTHILLS BELT, ALBERTA, by J. A. Allan and R. L. Rutherford; pp. 48, and 6-color map (Serial No. 5). Continuation of the field work in the area described in Report No. 6. **Price 75 cents.**

No. 11 (1924); GEOLOGY OF THE FOOTHILLS BELT BETWEEN McLEOD AND ATHABASKA RIVERS, ALBERTA, by R. L. Rutherford; pp. 61, and 8-color map (Serial No. 7). One inch to two miles. Continuation of the area described in Report No. 9. **Price 75 cents.**